TRANSPORT

Egon Larsen

PROGRESS OF SCIENCE SERIES

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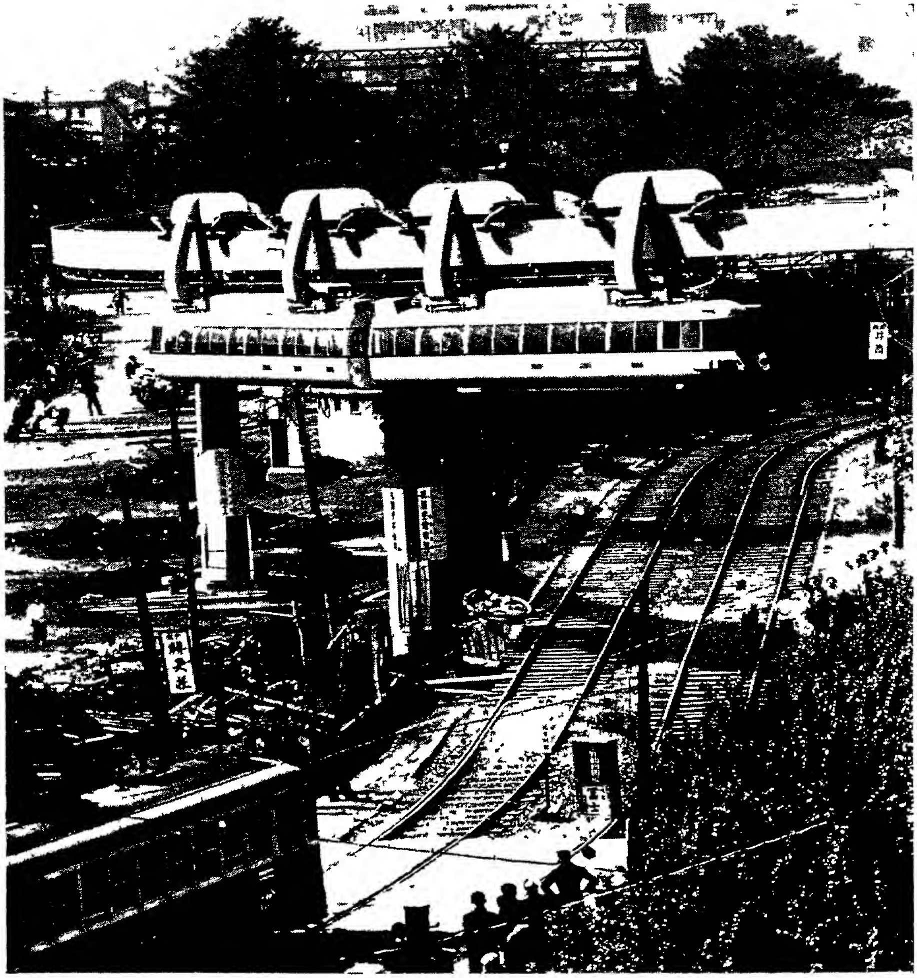

Tokyo's new overhead monorail train, which relieves traffic congestion in the streets.

PROGRESS OF SCIENCE SERIES

EDITED BY NIGEL CALDER

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Contents

Illustrations

IN TEXT

Drawn by John Mitchell

Wrapper photograph of London Airport by courtesy of British European Airways.

I. Going on Wheels

A STEADY STREAM of large, perspex-domed limousines glides smoothly along the highway. The drivers are not driving; they are reading the newspaper, looking at the scenery, playing cards with their passengers, or just dozing. As long as they are travelling over the motorway their cars are remotely controlled by an electronic device built into the road—a guide rail beaming invisible and inaudible orders at the transistorized receivers in the cars, keeping them in their traffic lanes at constant speed, and operating the brakes and steering gear if necessary to prevent a crash. Before the drivers enter the electronic motorway they set the point where they want to leave it for their final destination on a dial, and an alarm buzzer calls them back to the steering-wheel in time before the turning into an ordinary, secondary road is reached.

A vision of the future? Yes, but not an improbable one. American engineers are working out this system of cross-country motoring; it must eventually become a reality in order to end the frightful 'slaughter on the roads'. Every Christmas Eve, when millions of motorists are rushing home for the holidays, 600–800 Americans lose their lives in highway accidents. The electronic road is not just a stunt to sell more, and more expensive, automobiles; it is a necessity.

But motorists are not only killed on the highways; the toll is heavy enough in the towns, and car design will have to incorporate a number of essential safety devices, some of which have already been tried out with good results. A leading American insurance company has asked a team of experts to combine them in what they have called a 'survival car'. It may well become the standard motor-car of the future.

This model is powered by a gas-turbine instead of a piston engine, because a turbine can be much more easily controlled by automatic electronic devices which can check the speed when

necessary. It is steered not by a wheel on a column but by levers, like a tank or a child's sledge; thus one of the commonest causes of injury in a crash—the driver being thrown against the rigid steering-wheel—will be eliminated. The driver's seat is in the centre, for better visibility. The doors cannot fly open and spill the passengers on the road in a collision; each door has two sections which are hinged in the middle, and is secured by bolts. The passengers are 'packaged' in their seats; all of them, including the driver, are secured by aircraft-type safety belts, the seats have special padding, and one of them faces the rear. Tests have shown that passengers in a car of this kind would survive even a head-on crash without serious injuries.

There are other likely developments in car design. Car bodies will become lighter, probably made of plastic; tyres will be more durable, lasting up to 100,000 miles. Springs will disappear; a British car first serially produced in 1958 has neither coil springs nor leaf springs, wishbones, or any other of the complications which went with the conventional form of suspension—but rubber instead. Each of the four wheels is connected to an axial shaft which turns inside a steel housing; between the two is a rubber lining which twists with the shaft as the wheels go up and down on the road. This new system of 'springing' is said to last at least three times as long as the old one; it eliminates vibration and squeaks, and it does not need any greasing. Most important of all, it simplifies independent suspension on all four wheels.

There is, however, one development which we can safely discard; it is the atom-powered motor-car. A nuclear reactor even of the smallest possible size (which is determined by the 'critical size' of the atomic fuel charge) would cost many thousands of pounds. Secondly, the weight and bulk of the shielding necessary to prevent the driver and passengers from being irradiated to death, would be prohibitive for a small vehicle such as a motor-car. Even if these difficulties could be overcome—would a nuclear car be a good idea? When the first steam-engines came into use some inventors built them into road-vehicles. They failed because the particular properties of the steam-engine were unsuitable for the requirements of road traffic. Much the same can be said about the idea of an atomic car. However, petrol-engines may not survive for very long; the gas-turbine seems to be the most suitable and

economical prime mover for the purpose once its problems—heat, noise, and high fuel consumption—have been solved.

In Britain, electronic motorways may not yet be around the corner; but something will have to be done soon about the congestion on the existing roads. Every motorist who has enjoyed a holiday in the country can tell a tale of woe about the dismal crawl back to town at the end of a Sunday or Bank holiday when roads are jammed for miles and miles. Britain's seven million motor vehicles need more space; and every month there are 20,000 more to add to the congestion.

In 1947, Britain had one car for every 24 people; ten years later, one car for every 14 people. The United States had one car to every 5 people in 1947; today the 'three-car family' is no longer an exception, and by 1975 the U.S.A. will have an annual production of 6.5 to 7.5 million cars. New Zealand has now achieved the car density which America had in 1947, while Canada and Australia are approaching the two-car-per-family era. France more than doubled the number of her cars from 1947 to 1957. All over the world, the number of cars increases by about 15 per cent per annum.

Where is the limit, and when will it be reached? How many cars does the world need—and how many can it afford?

It is not just a question of money; the problem is that of space. If my doorstep were leading on to the wide open spaces of Asia or Africa I would not be aware of any difficulty; but being a town-dweller I cannot help worrying about the future of urban transport, and this goes for millions of people in big towns all over the world from New York to Paris and from Manchester to Munich. Tokyo is in the same predicament as Los Angeles, and Moscow, too, will have to face it sooner or later. Man, that inveterate sorcerer's apprentice, loves to conjure up forces which he cannot control, and to get into a proper muddle by trying to make life easier for himself.

We can fly from London Airport to Le Bourget in three quarters of an hour, but the journeys from and to the town centres of London and Paris add another two or three hours to the trip. When Sherlock Holmes sped in his hansom cab across the metropolis to the scene of some crime he might have wished for some faster, mechanical means of transport, but today it would take him just as long to get there.

Congestion on the roads is the great headache for the town planners and transport experts; the problem has to be solved soon if the wheels of the big city are not to come to a standstill one day. Chaotic conditions, mounting numbers of street accidents, inconvenience all round for all types of road users are the penalties we have to pay for letting things slide, for just sitting back and hoping for the best. Our modern towns originate from medieval settlements, usually built with an eye on strategic needs: in those days, cities had to be as compact as possible within their protective walls. Before the advent of mechanized transport the narrowness of the old streets did not matter so much; now it threatens to strangle the whole life of the town.

What has been done, and what can we do about it?

We can pull down the ancient centres of our cities and replace them by wide squares and avenues. But who would have the heart to do this? In some cases, the last war has done the job for the town planners. As for the rest, the police have tried to cope with the flood of traffic as best they can, introducing one-way streets, parking bans, parking meters and the like. In a number of towns, vans and lorries may not unload or load in the centres during the day. But if we want to fight the congestion with purely administrative measures nothing short of banning all private vehicles during working hours will do. Car owners would have to leave their vehicles at home or in car parks on the outskirts of the town, and proceed by public transport; Hamburg operates special buses between its suburban car parks and the city centre. Even a much increased number of buses, coaches, and trolley-buses would not cause congestion nearly as bad as that due to unrestricted private-car traffic in our big cities.

Another solution, rather popular with the town-planners but not so much with the town-dwellers, is the 'satellite' system. The idea is to draw as many people as possible away from the big towns and settle them in new, carefully planned communities which cater for modern, instead of medieval needs. As a rule, such satellite towns—England and Germany have already a number of them—provide housing as well as employment; factories are spaced around the residential districts, easily accessible, and the town centre itself, with its shops and public buildings, is in many cases completely free of traffic so that the pedestrian can walk around

without any fear of being run over. Selected streets in these satellite towns are also trafficless playing-streets for children.

All this sounds very tempting and pleasant, but people often prefer the inconveniences of metropolitan life with all its hubbub and chaotic traffic to the quiet and order of an 'artificial' community. Some of us, it seems, are incurable big-townsmen. On the other hand, there is some resistance on the industrial side; many industrialists fear that skilled workers might leave their factories and go to the new ones around the satellite towns.

But we do not know how future generations will feel about moving out of the big cities and into the new satellite towns. In his famous book, *The Foreseeable Future*, Sir George Thomson, the physicist and Nobel-prize winner, says that the impossibility of solving transport difficulties will force people to settle in communities of about 50,000 enabling a man to live at ten minutes' distance from his job. This, he believes, will call for much more effective communications which are likely to depend on television so that people working in different communities can still be in personal contact with their superiors, colleagues, and employees.

Of course, big towns such as London or Tokyo or New York will hardly split up into smaller communities in the near or distant future. But if they want to remain more or less as they are, they will have to make greater use of the underground tunnel—for 'tube' railways, cars, or pedestrians. So far, only the railways have used the tunnel system to any extent, but we are now at the beginning of a new development.

Even at the time when London's first underground railway was being built—in the 1860's—an American put forward the idea of transporting people under the pavement by a system of moving-belt conveyors. Known under its French name, *trottoir roulant*, it made brief appearances at international exhibitions and similar events, but was nowhere permanently installed. Later, the idea was believed to have been superseded by the underground railway, or subway as it is called in America, which can transport a larger number of passengers at great speed and in complete safety.

Modern developments, however, favour the revival of the *trottoir roulant*, now called 'speedwalk', and of the related 'carveyor'; it may be useful anywhere in a town where people have difficulty in getting to their destinations above ground, but where

distances are too short for a journey on the underground railway.

The speedwalk is, in fact, a mechanical escalator which conveys its passengers horizontally instead of up or down, but it can also overcome slight gradients. It works roughly like this:

You enter the speedwalk 'station' by stepping on to a platform moving at $1\frac{1}{2}$ m.p.h., which is about half the normal walking speed. Alongside the platform, and at the same speed, moves an endless row of seats; you will have no difficulty in sitting down. As soon as the seats have moved out of the 'station' they pass over a bank of 'accelerator wheels', which steps up their speed to 15 m.p.h. and spaces them out into 'cars' of two or four seats each, very much like the cars of a scenic railway on a fair ground. Before they enter the next station the cars pass over another bank of wheels which decrease their speed down to $1\frac{1}{2}$ m.p.h., and at your destination you will step out on to a platform again moving at the same speed, and from there to solid ground.

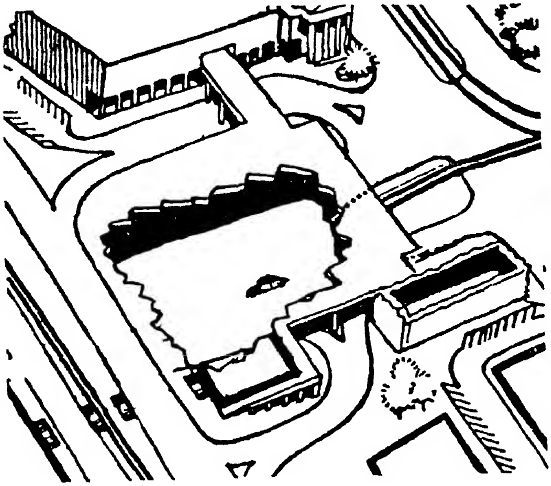
The first speedwalk of this type was installed in Jersey City in 1954, connecting the railway station with the underground trains; it negotiates a 10% gradient and carries up to 10,800 passengers an hour. A sports stadium in Chicago has eight short speedwalk units which carry people to their seats on the stands, and many other speedwalks have been built or are in preparation in crowded American cities, most of them underground, but the system can also be used at street level or on elevated bridges at first-floor level to reduce congestion on the pavements. Another use may be that in large department stores to carry shoppers between departments.

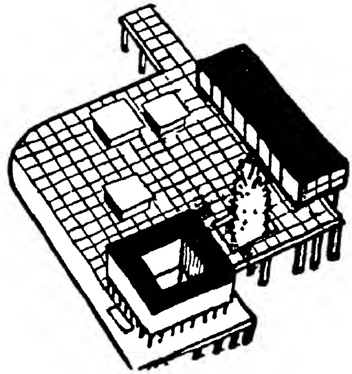
The 'carveyor'—the first of which was built in 1958 between Times Square and Grand Central Station, New York—operates on a slightly different system. You step on to a 60-foot long speedwalk moving at $1\frac{1}{2}$ m.p.h. and from there on to one of a series of small cars running on rails and moving at the same speed; they have doors which open automatically and close as they leave the 'station'. Each car seats eight people. Here, too, are banks of accelerator rolls which increase the speed to 15 m.p.h. or slow it down to $1\frac{1}{2}$ m.p.h. before the next station is reached.

These systems are, in fact, the first examples of complete automation in public transport: there are no drivers or signalmen, no guards or station-masters.

A direct descendant of the *trottoir roulant* is London's 'travolator',

a two-way moving pavement for the horizontal conveyance of underground passengers between platforms. The first 300-foot travolator was built between two sections of the Bank tube station in 1959.





Stuttgart's traffic 'Lid'. Right, details of the 'Lid'.

By 1962, the town of Stuttgart in south-western Germany will have a unique feature, a 'lid' over its busiest square. Covering the street level with its mechanized traffic it will be reserved exclusively for pedestrians. At first-floor level, they will find a quiet retreat with plants and flowerbeds, water basins and benches. The tops of the ground-level trees will peep through holes in the 'lid', and a building on stilts will contain shops and cafes. Pedestrians will probably prefer to cross the square via the 'lid', especially if escalators are provided.

Relieving street congestion by diverting people and vehicles to first-floor level will most likely become an accepted method. Years ago, engineers and science-fiction writers were dreaming of roof-top motor-roads, but until the buildings in our towns are all more or less of the same height—which would make their silhouettes somewhat monotonous—there is little chance of such an idea becoming reality. However, pedestrian lids over roads, or roads over roads, at a height of 20–40 feet above street level, will be one of the features of tomorrow's towns. Britain's first double-decker

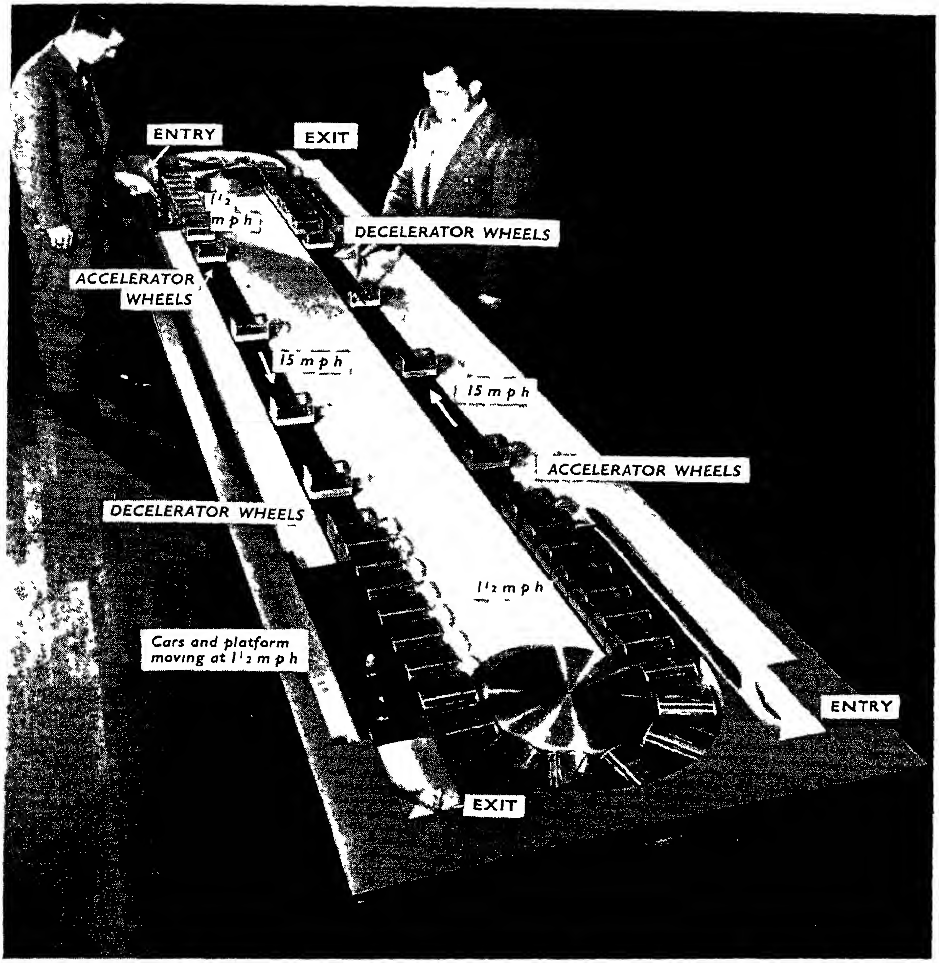
road project was started in 1958; it is the London end of the South Wales road and will also provide a new fast route to London Airport. Built on a viaduct with single supporting piers it will run at an average height of 25 feet for 12½ miles above a new westbound motor-road. For the first mile the upper deck will cover the existing Great West Road like an umbrella. Where it has to cross a large factory it will rise to a height of 65 feet.

Crossings are the great bottlenecks in urban traffic. There are two ways of rendering them harmless: by building underpasses or fly-overs. They allow the motorized traffic to continue under or over a crossing without speed reduction; those cars which want to turn right or left take a short rising or falling branch road which conveys them to the level of the upper or lower street.

Stockholm is an excellent example of the intelligent use of this system; so is Paris, which has built underpasses, some fairly long tunnels, along its *zone*, the ring road which has taken the place of the city's ancient fortifications. London is only beginning to build underpasses on its circular roads, and tunnels such as the one under the continually congested Piccadilly.

Public road transport must stay at street level to pick up and set down passengers, but it benefits indirectly from underpasses and fly-overs because they take other traffic out of its way. Today, a single person in a private car occupies six times as much road space as a passenger in a fully loaded double-decker bus. Besides, many thousand motor-cars parked in the city's streets are hampering the movements of millions of public transport passengers in the buses. When traffic gets chaotic the largest group of people affected are those who use buses for their daily journeys to and from work. It is, therefore, difficult to see how we can get around some form of private-car ban if street traffic increases at the rate it has done since the mid-thirties; the number of private cars in Britain has doubled since then, and it may double again before the century is out.

One way of easing the situation would be the building of new underground railway lines, but the cost seems to be prohibitive; still, the famous plan of adding a new cross-London connection from Victoria Station to King's Cross may one day become reality. Apart from this, there is little scope for improvement in London's underground railway system, which is considered the best in the



1. A model of the Carveyor, in which passengers making short journeys would step on and off cars travelling on a continuous moving belt.

2. The car of the future? An artist's impression of completely automatic driving on the electronic highway.

3. Traffic control by TV at Durham a police officer sees on a TV screen in his kiosk vehicles approaching from the narrow streets leading into the Market Square.

world. New York, however, has only in the 1950's begun to improve its outdated system; eventually it will have platforms which are completely shut off from the rails during train intervals, with doors that will open only when the train doors open; the carriages will be lit by germicidal lamps, and air conditioning plant will keep the air sweet; there will be soft music on the otherwise noiseless journeys, interrupted only by the charming voices of girl announcers giving the name of the next station. In addition, the walls of the tunnels will have distinct colours at the approaches to the stations so that the passengers know when they are nearing their destination. The new Leningrad underground will be remotely controlled from a central point; the trains will have no drivers.

Such conveniences do not, of course, solve basic problems such as that of balancing a railway system between over-demand during rush hours and under-demand during the rest of the day. There are, for instance, trains which are unused 90 per cent of the time; all they have to do is one trip of about twenty miles in the morning and one in the evening, five days a week. The same problem haunts the bus services. A third of London's buses and trolley-buses are never needed outside rush hours. However, there is little one can do about this; passengers have to be carried, profit or not.

But there is another source of waste which may soon be stopped. One fifth of bus running-time in Central London is spent waiting at traffic lights; this is almost twice as much as the time spent in picking up passengers. Enormous amounts of fuel are thus wasted, for the engines must be kept running during these stops and have to be stepped up again to full performance every few minutes. The answer to this particular problem is the fly-wheel.

Such a wheel, about two feet in diameter, is mounted between the engine and the rear axle. It 'stores up' the energy lost when the bus slows down; it goes on turning while the vehicle is at rest, and the stored-up energy can be 'extracted' and put to work again when the bus moves on. Thus up to 50 per cent of fuel consumption can be saved, and acceleration to higher speeds will be faster. The fly-wheel, of about 250 lb. weight, spins in a vacuum casing at up to 15,000 revolutions per minute. The bus is slowed down by coupling the engine to the fly-wheel, which is thereby speeded up; in this way the forward energy of the bus is not lost but stored up in the wheel. On restarting, the spinning fly-wheel is geared

to the rear axle and assists the engine to accelerate the bus up to top speed; then it cuts out automatically, and the vehicle is driven by its engine in the normal way. When it is garaged at night the fly-wheel is left spinning—it will still be spinning the next morning, having lost little of its speed, and it can then be used to start the engine.

In our age, with atomic fission and eventually fusion energy (the utilization of the H-bomb power for the production of electricity) promising current galore, electric trolley-buses are taking on a new importance. They do not waste much energy; their engines do not keep running at stops. They are reasonably manœuvrable in the streets, and they do not poison the air with exhaust fumes. Their disadvantage, however, is the necessity for costly overhead installations; and when there happens to be an electrical breakdown the trolley-buses become immobilized. Another point is that routes cannot easily be altered or extended, or detours made round road repairs. The argument for and against an increased use of trolley-buses in town centres is far from settled, but in the outskirts the balance seems to be very much in their favour.

Electronics are playing an increasing part in traffic control. London Transport has developed a scanner which records buses as they pass a series of points on their routes; by means of a photoelectric cell each bus is 'recognized' and its number transmitted to a central station, and here an electronic brain compiles a continuous overall picture of the progress of the vehicles, which can be spaced out, slowed down, or speeded up according to the prevailing traffic situation. This gives the service a new flexibility and accuracy of control to cope with demands and difficulties as they arise. Instructions to the inspectors along the routes can be telephoned or radio-telephoned.

Traffic lights are also entering a new phase of development. At present they are working on a fixed time cycle—say, two minutes green in one direction and 90 seconds in the transverse one—or according to the flow of traffic: vehicles running over rubber pads in the streets 'tell' the traffic lights that they want to cross. But these traffic-operated lights cannot 'look ahead' and take no account of the speed of approaching vehicles.

A new system, first installed in London's Oxford Street, groups the lights together so that traffic can flow at a steady pace. But

there is scope for further improvement. Photo-electric 'detectors' will eventually take over, providing information about approaching vehicles when they are still one or two street blocks away, and about the speed at which they are travelling. Fire engines, ambulances, and police cars will be equipped with V.H.F. transmitters which, by acting on receivers in the traffic lights, can change them to green at a distance of 100 yards to give right of way.

Closed-circuit television may also play a part in traffic control. The first permanent television traffic control point was brought into operation in Durham in 1958, providing the policeman on traffic duty in his kiosk in the Market Square with a 'third eye'. The streets leading to Durham's central square are rather narrow and crooked; previously, the traffic policeman had to operate the signals without knowing how much traffic was approaching from either direction. Now he only has to look at the two television screens in his kiosk to see what is happening around the corner. The screens are connected by cable with two cameras set up in the streets leading to the square.

After Durham, Munich in Germany installed a television camera to watch its main square, one of Europe's busiest crossings in a narrow city centre. The receiver screen is several hundred yards away at police headquarters; from here, a central switchboard can control all traffic lights in the city and, with the additional aid of patrol car radio reports, regulate the flow of traffic.

Another electronic device in traffic control is the radar meter which helps to check motorists who defy the speed limit. It was first used in Lancashire and in the outskirts of London in 1957–58. The little boxes were set up on tables along roads with specially bad accident records. They register the speed of vehicles automatically, and police officers note the numbers of speeding drivers. The immediate results were a marked decrease ($12\frac{1}{2}$ per cent) of accidents. There was the same result in an American state as soon as the police put up a notice that radar meters were now in use. In fact, the manufacturers had been unable to deliver the little boxes in time. They were only put up a month later!

Roadmaking is expensive. There are not only the work and materials to be paid for but private property to be bought. An ordinary motor-road costs between £200,000 and £300,000 a mile, and in built-up areas nine-tenths of this is the price paid to acquire

the land and demolish the property. Also, bottlenecks such as old towns must be avoided by means of by-passes, which further add to the cost.

For this reason, some experts believe that the solution may be 'roads over railways'. Long-distance motor-roads could be built over the existing railway tracks from the outskirts or even from the centres of our big cities across the country; this would be much less expensive than the construction of entirely new roads, if only for the reason that no property would have to be acquired. Such 'highroads' could be built on mass-produced reinforced concrete pillars and road slabs. The first road over a railway will be a three-mile stretch across Oldbury, near Birmingham. If it is a success, a vast ring road over London's railways, with large parking spaces, may come next.

There is always a great deal of work to be done to keep existing roads in good shape. Britain is still using the road-building methods of her two eighteenth-century pioneers, Telford and Macadam, although in a modified manner; much of the present-day roadmaking technique is a result of the experience gained in building airfields before and during the last war.

The preparatory stage, the survey of the route and the analysis of the kind of soil which the engineers will encounter, is perhaps the most important one. The 'bearing-power' of the ground must be assessed, the material to be used (preferably local stone) and the most suitable machines have to be decided upon. There are, for instance, the so-called 'single-pass' machines for laying the soil-cement road base, and 'finisher' machines for laying asphalt. The top layer of a modern first-class road is usually asphalt or 'coated macadam' to give it a dust-free surface, and secondary roads are sprayed with tar or bitumen and finished with scattered chippings—also mechanized operations—to keep them in good, dust-free condition for years. Another up-to-date material is concrete, which does not require any special surface layer if it is of high quality; here, the experiences gathered in runway construction have been put to good use.

Cross-country roads must be constructed with a view to reducing the danger of skidding in the rain; smooth roads may be dangerous—the sharp points of broken stone or sand are important features of a safe road because they give the tyres a good grip.

Every year the average speed of car travel increases by about one mile an hour; the road engineer must therefore look into the future when selecting the material for his road surfaces. Special research cars, with a built-in extra wheel for measuring resistance of wet road surfaces to skidding, provide him with the necessary information.

If there were only motor-cars and aeroplanes available for long-distance transport today, and someone came along with the idea of building railways, he might score a sensational success. This inventor—let us call him Mr Stephenson—could point out that his new means of transport would combine a maximum of safety and comfort with a minimum of inconvenience. The railways, Mr Stephenson would say, would operate under almost any weather conditions; they would take the travellers from city centre to city centre; there would be no more fastening of seat belts and passengers could move about, for instance to a special car equipped as a travelling restaurant. From their comfortable seats the tourists would see the towns and villages in passing, almost as on a television screen, and they would meet some of the people of the country through which they are travelling as they come into the tourists' compartment. The traveller would not have to drive himself as when going by car, he would not have to worry about the route, about detours, about the strain of driving by night, about parking or garaging his car on arriving—and certainly not about cleaning and servicing it. There would be hardly any unpleasant surprises such as breakdowns, costly repairs, and other holdups which might delay his arrival and throw his timetable into confusion. He could, in fact, safely go to bed on the journey and sleep through it.

I believe Mr Stephenson's idea would be hailed as the most modern notion of what transport should be. However, our lack of appreciation of rail transport—and this includes the moving of vast quantities of goods by freight trains—is probably due to the fact that it's nothing new. It takes some spectacular new development to draw public attention to the advantages of rail travel.

Such a new development has already started; it is the monorail system. The idea is not a new one; as early as the beginning of this century engineers believed that trains using only one rail would be cheaper and faster than the conventional two-rail ones. It was then

thought that such a train could be prevented from toppling over by 'gyroscopic inertia': a gyroscope, or fast-spinning wheel suspended in such a way that it is free to rotate about any axis, would keep the train upright like a spinning top. But this system was found to be unsafe; if for some reason the gyroscope stopped the train would crash.

Another idea, the 'railplane', or overhead suspension train, has already been put into practice in various towns: in the industrial Rhineland, in Tokyo, and experimentally at Houston, Texas, and at Milngavie, Glasgow. This type, however, requires a fairly heavy and expensive superstructure.

The most promising monorail system seems to be that developed by a group of German technicians and backed by the Swedish-American millionaire, Axel L. Wenner-Gren. The 'Alweg' railway (so called after the initials of its backer) was thoroughly tried out on its experimental track near Cologne in the early 1950's, and actual full-size tracks are in construction in Brazil, Canada, Tanganyika, and other countries. It has also been considered as a possible link between London Airport and the West End air terminals, thus eliminating the tedious coach journey to and from the airport, which by 1970 is expected to handle twelve million passengers a year.

The Alweg train runs along an elevated concrete rail beam on which it is firmly kept by flanges and rollers. The coaches are diesel-driven, and capable of running singly or in two or three units. They could be controlled by drivers or remotely. At the end of the monorail track they could continue their journey on the road as coaches, and set down their passengers right beside the airliners. Theoretically, the speed could reach 250 m.p.h., but for safety reasons it may be kept under 100 m.p.h. The cost of building a monorail track is only about half of that for a conventional railway line (and 20 per cent of that for an underground railway). Those who have travelled over experimental monorail tracks say that the journey is extremely smooth without any jolting or rolling, and the transition from the monorail to the road and back is hardly noticeable.

The difficulties of utilizing atomic energy in rail transport are not nearly as great as in the case of the motor-car. Some German and American companies are studying the problem, and blueprints

of possible nuclear locomotives have already been published. The American one would be about 160 feet long, with 30 wheels, and weigh 327 metric tons; the reactor, running on liquid-uranium fuel, would measure 2 by 3 by 3 feet, and the steel shielding, weighing 200 tons, would have to be 4 inches thick. Operating for one year on 11 lb. of uranium the engine would develop 7,000 h.p., or four times the power of a comparable diesel-electric locomotive; the cost would only be twice as much. The heat from the reactor would be transferred to steam-turbines geared to electric generators. The German type would have only 16 wheels, weigh 185 tons, and develop under 6,000 h.p.

Such an engine could be built and work satisfactorily. But would it be worth while, except perhaps in countries with very wide open spaces and enormous distances between stations, so that electrification of the lines would be forbiddingly expensive? Only in such areas could there be any sense in using atomic energy in locomotives. In all other countries the present trend seems to be towards electrifying as much of the rail network as feasible (while running diesel-electric locomotives on the non-electrified lines)—and building nuclear power stations to supply the current, which looks like a more sensible way of utilizing atomic energy for the railways. There is also the danger that a railway accident might spread radio-activity over a wide area. Fascinating as the possibilities of nuclear energy are in many fields, there would be no point in imposing it on means of transport which can provide perfectly satisfactory and economical service with conventional sources of power.

This does not mean, of course, that Britain's railway system is already as good as it ought to be. On the contrary; it has taken us much too long to finish the first chapter in the development of rail traction—that of the steam locomotive. It was certainly a technical marvel in its youth, but in its old age it is no more than a dirty, inefficient, noisy, and smelly relic from the past. Quite rightly, Britain is building no more steam locomotives. For all the romantic atmosphere of the hiss and puff the coal-burning railway engine has contributed much to the pollution of the air in our cities. It is an incredible fuel waster; apart from the fact that it converts only 12 per cent of its fuel energy into power (comparative figure for the diesel-engine: 36 per cent) it burns up its fuel

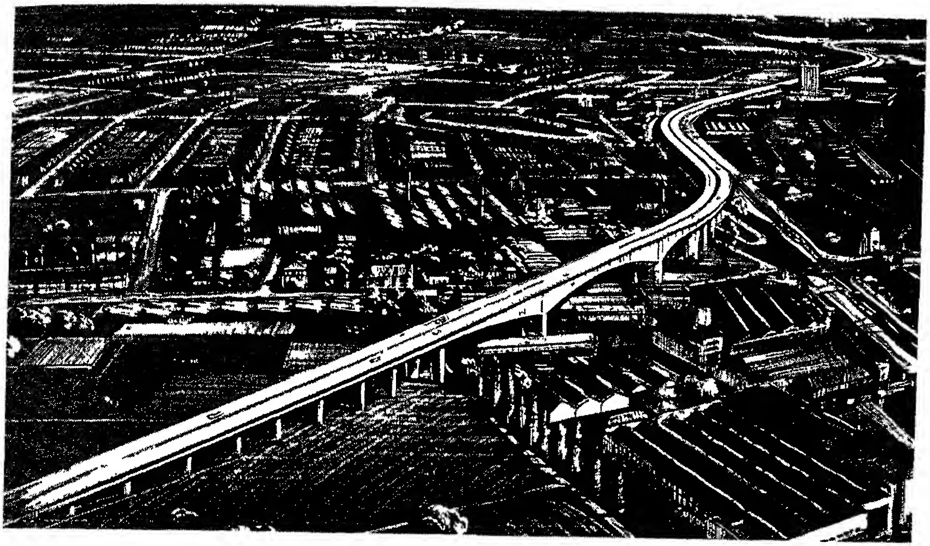
a long time before and after work—you can't switch it on and off like an electric engine, which consumes energy only when and as long as it works. Yet a substantial part of railway traction in Britain is still being done by coal-burners, while in America about 90 per cent of the railway passenger service is provided by oil-burning, electric, and diesel-electric locomotives. The first of these types, the oil-burning steam locomotive, is being pensioned off as fast as possible along with the coal-burning engines; with oil-burning steam-engines it takes two tablespoons of oil to move a ton of freight a mile; a diesel-engine does the job on no more than two teaspoons of oil!

For countries like Britain, which will have an abundance of nuclear-generated electric power at her disposal, the electrification of the railways is the obvious solution. But there are many problems to be overcome, some of which may sound surprising to the layman. For instance, no fewer than eighty bridges had to be modified on the thirty-mile line between Crewe and Manchester. Tracks, platforms, and of course the signalling system have to be reconstructed.

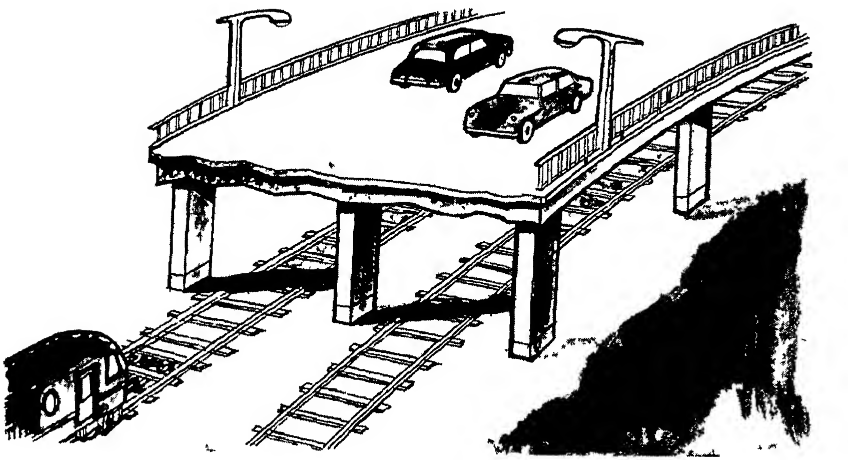
Electric locomotives have reached a very high standard of efficiency, but there is still room for further improvements. Like the internal-combustion road vehicle, the electric railway engine will benefit from the fly-wheel which stores up energy. The 'electrogyro locomotive', which is already in service in a number of countries, has a fly-wheel which is brought up to speed by automatic coupling to the electricity supply. The gyro-motor then acts as a generator and supplies additional power to the traction motors of the locomotive.

Where electrification is too expensive or too difficult, the diesel engine in one of its various forms seems to be the most economical machine. Prototypes of gas-turbine locomotives have been running in Britain, America, Russia, and elsewhere. They are, strictly speaking, gas-turbine-electric engines (with generators and motors as in diesel-electrics) because the direct application of turbine power to the axles is difficult. The advantages of the gas-turbine are high power output, use of cheap fuels (including pulverized coal), and low maintenance costs.

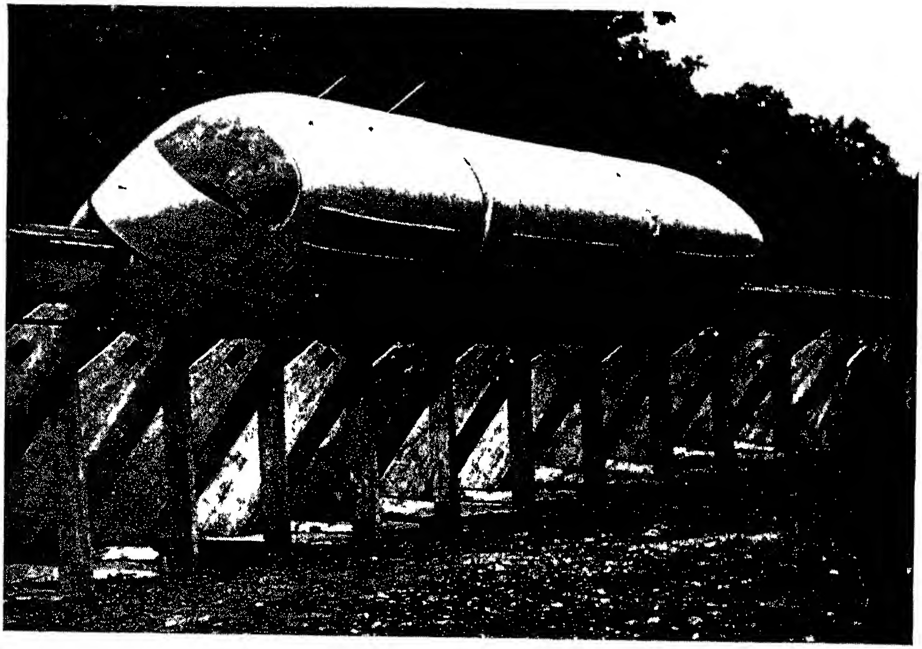
The diesel-electric locomotive, in which the internal-combustion engine is used to produce electric current for the traction motors,



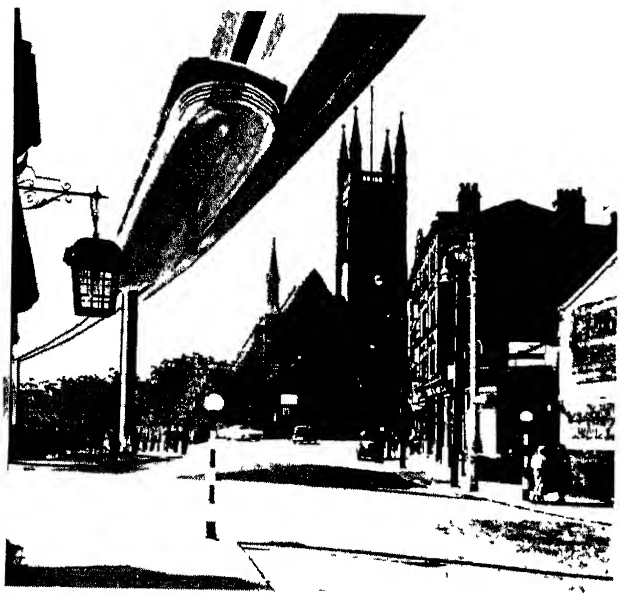
4 The London end of the new South Wales Motorway. It takes the traffic into and out of London partly at roof-top level.



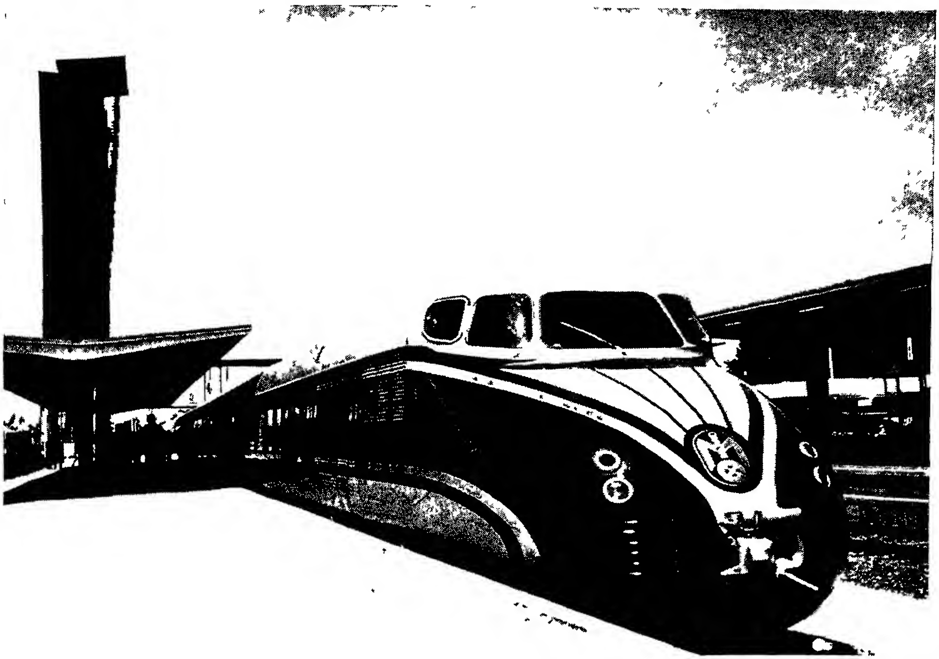
5. Roads-over-railways—a new idea to relieve the crowded roads around the big cities and across the country.



6. The Alweg Railway, a monorail system devised by a Swedish industrialist, who says it may be developed to reach speeds up to 180 m.p.h.



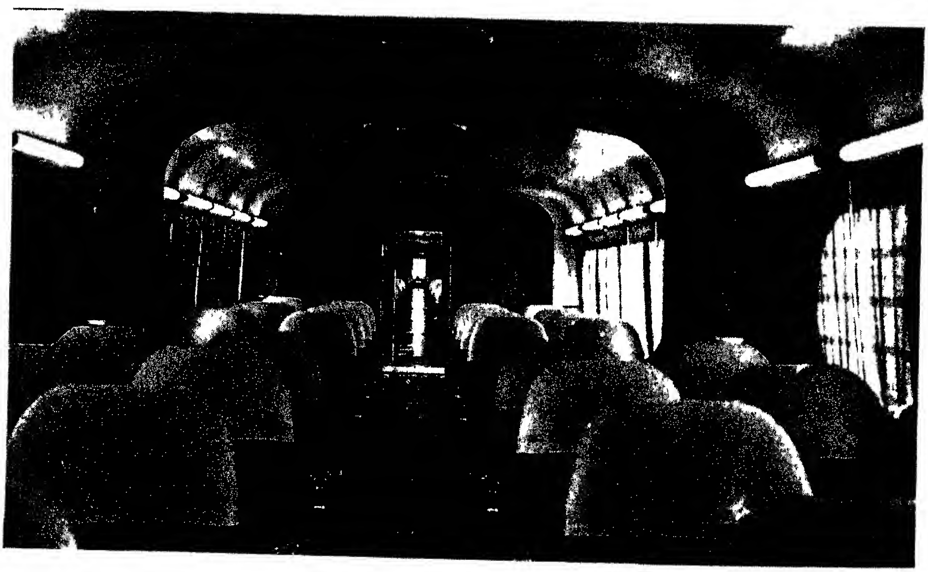
7. An overhead monorailway in London? This is an artist's impression of what such a railway would look like crossing Queen Caroline Street, Hammersmith.



8. 'The Comet', an articulated diesel-electric train of the German Federal Railway.

9. France's world rail speed record-holder the electric locomotive CC 7107, which has reached 205 m p.h.

10. The 'Aerotrain', America's lightweight passenger train, which weighs only half as much as conventional express trains.



11. Interior of the articulated 'Talgo' train connecting Madrid with the North of Spain

is a favourite in many countries, especially America. Now it has a serious competitor in the diesel-hydraulic locomotive, which has been extensively in use in Western Germany and has been introduced in British Railways' Western Region between London, Plymouth, Bristol, and Penzance. By making the transmission hydraulic—that is, using fluids under pressure instead of a motor-car type of gearbox (which would be unsuitable for a locomotive)—the designers have achieved a high level of efficiency at all speeds; it is much lighter than the diesel-electric engine and requires less maintenance. A diesel-hydraulic locomotive with two 1,000 h.p. engines can easily attain a speed of 100 m.p.h. with a fully loaded train.

Britain has been slow to abandon her time-honoured coal-burning railway engines because during the first hundred years of railway development coal was cheap and plentiful. France, on the other hand, has large hydro-electric resources, and therefore railway electrification began early in that country and has been stepped up since the last war. French railways, once an ideal subject for cartoonists because of their backwardness, are now the fastest and most modern in Western Europe; French electric trains hold the world record with speeds of well over 200 m.p.h.

French railways have introduced a number of interesting improvements such as the 'pneumatic' train, which runs on motor-car tyres, thereby achieving extraordinary smoothness, or the 'pendulum' carriage—a coach that can bank like an aeroplane when negotiating curves. It is set on a central axle and can sway up to 18 degrees to either side of the vertical; thus the train does not have to slow down on sharp bends, and there is no discomfort to the passengers—in an ordinary train they are flung outwards by the centrifugal force. The new coach will serve on long high-speed runs such as that of the Paris–Lyons express, which averages 85 m.p.h.

Those who regard the railways, despite their obvious advantages, as an outmoded form of transport point to the fact that during the last fifty or more years their speed has hardly increased, and that it will not increase very much in future either. This is, of course, largely true. We have mentioned the world speed record held by French electric locomotives; the fastest regular run, however, is that of an American diesel train with an average speed of 86.2 m.p.h.

over prairie country. But the overall average speed of American passenger trains is still below 40 m.p.h. An excellent achievement is the longest daily non-stop run in the world, from London to Edinburgh—nearly 400 miles—which is covered by a 400-ton train with eleven coaches at an average speed of over 60 m.p.h. However, this is not very much above the speed achieved on the same run at the end of the last century.

Where is the speed barrier of a railway train? There is no general answer to this question, but it seems that something like 200 m.p.h. will be the maximum where the line is relatively straight and level like that from London to Edinburgh. But it cannot be reached merely by increasing the traction power of the engines. There are many technological problems to be solved. One is the weight of the train, especially that of the wheels. An American train, the 'Aerotrain', weighs only about half as much as conventional trains; the car bodies are made of light alloys, and the steel springs are replaced by large rubber bellows so that the passengers 'ride on air'. France's rubber-tyred wheels have raised the question whether the whole rail system might not one day be replaced by concrete pathways for the wheels with a separate guiding-rail in the centre (experiments on these lines have already been carried out on the Paris underground, with marked success). We have already discussed the monorail system; perhaps the answer to our problem lies here.

A train employed on daily runs in Spain has been built with only two independently sprung wheels per coach; each coach is 'articulated' to the one in front and behind. On the uneven and winding Spanish railroads this type of train allows for much greater speed than a conventional one.

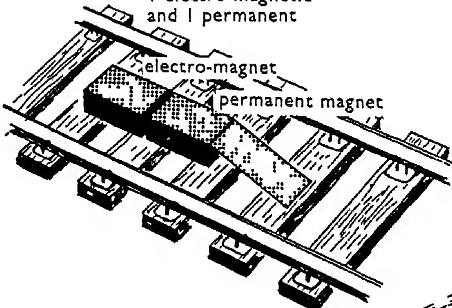
Another difficulty which prevents higher speeds is the human element in train control: so long as the driver alone is responsible for the safety of his train, speeds must be limited; for he can be sure only that the section of the line immediately ahead of him is clear. With increasing electrification all trains on a main line could be remotely controlled from a central switchboard from which the state of the entire length of the line can be overlooked—by human as well as electronic eyes.

However, it will be some time before most of Britain's and America's rail networks are electrified, but automatic train control

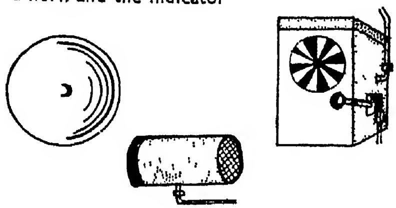
AUTOMATIC TRAIN CONTROL brings the distant signal onto the foot plate
The new system is entirely automatic—there is no physical contact with the locomotive at all

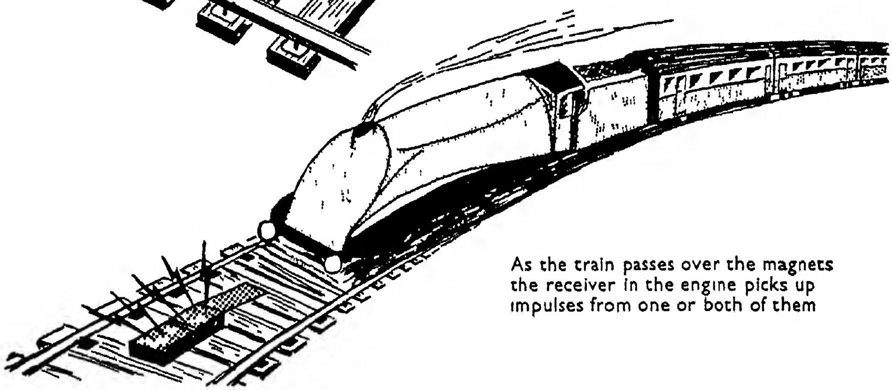
THE EQUIPMENT

ON THE TRACK 2 magnets
1 electro-magnetic
and 1 permanent



IN THE ENGINE CAB a bell, a horn and the indicator



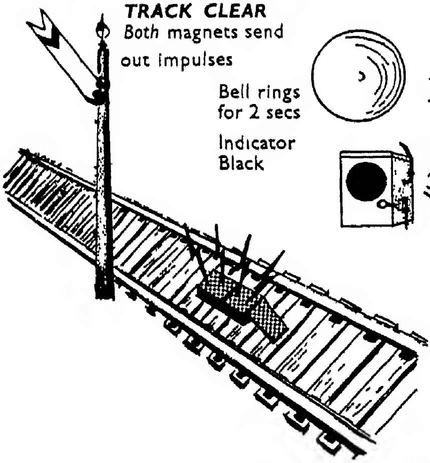


As the train passes over the magnets the receiver in the engine picks up impulses from one or both of them

TRACK CLEAR
Both magnets send out impulses

Bell rings for 2 secs

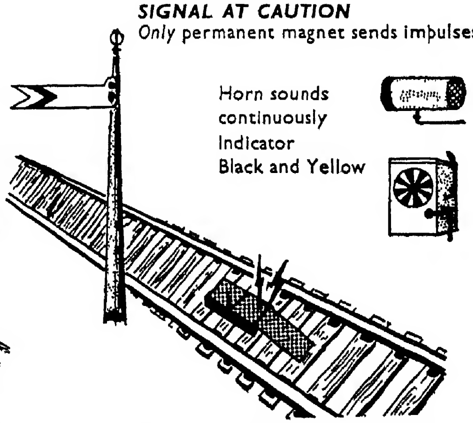
Indicator Black



SIGNAL AT CAUTION
Only permanent magnet sends impulses

Horn sounds continuously

Indicator Black and Yellow



If the driver does not act in 3 secs the brakes are automatically applied

(A.T.C., as the engineers call it) is a 'must' in modern transport. For this reason, the system which has been introduced in Britain is one that works with steam or diesel trains as well as electric engines. Two magnets adjacent to each other are fixed in the centre of the track, 200 yards on the approach side of the distant signal. The first magnet is a permanent one, and the second an electric type controlled by the position of the signal arm. On the locomotive, a 'receiver' responds to the magnetic fields of the track magnets. The system is not meant to relieve the driver of his responsibility for observing signals, but it will aid him, especially in bad weather. On approaching a signal in the 'clear' position a bell rings in the driver's cab; if the signal is at 'caution', a horn sounds continuously in the cab until the driver presses a re-setting lever: this activates a visual indicator in front of the driver, reminding him that he must be prepared to halt at the 'stop' signal if it is against him when he reaches it. Should he fail to press the lever within three seconds, an automatic brake valve comes into action and halts the train.

Britain's railways will have to become more efficient and economical if they want to compete successfully with road transport —that is, without losing money. Her railway network of 1970 will probably be much smaller after uneconomical lines have been rigorously closed; but the remaining system will be used much more intensively; mechanized handling of goods will have been introduced, modern marshalling yards built, and there will be fewer but more highly trained railwaymen.

Passenger services are, of course, only part of the business of a railway network. Freight trains will have to run faster, and there will be efficient equipment for the road-rail transfer of goods. Britain's industrial production may increase by as much as 60 per cent by 1970, and the railways must play their part in moving 'bulk' goods such as minerals, coal, and raw materials over long distances. There is no doubt that they can do this more cheaply and faster than road transport.

Western Europe's international transport will be completely transformed once that age-old engineers' dream becomes reality— the Channel Tunnel. Napoleon was the first champion of this idea, which was submitted to him by a French engineer in 1802. He discussed it with the English statesman, Charles James Fox— tongue-in-cheek, for Napoleon thought of the tunnel mainly as an

invasion route to England. However, the project turned out to be technically hopeless with the limited mechanical means at the engineers' disposal. But it has cropped up innumerable times ever since, and in the 1880's two pilot tunnels, one from Dover and the other from Sangatte, were actually driven forward for a mile or two until the British public and many generals and statesmen were seized by a panic: England's 'splendid isolation' was at stake, the defence of the island fortress was to be undermined! Work ceased, but the idea lived on.

Today, in the age of the nuclear bomb and the guided missile, the Channel Tunnel seems hardly a military threat, and the defence chiefs are no longer worried about it. Only economic and financial difficulties have prevented its realization; but there is a good chance that they will be overcome, for the advantages of such a link would be very great indeed. The train journey between London and Paris would be cut by two or three hours, with no annoying and time-wasting change from train to boat and from boat to train to overcome a mere thirty miles of water. Perhaps even more important than the railway link would be the road link; with a submarine motorway connecting Britain and the Continent goods could be collected and delivered by van all over Europe without reloading, which would make them much cheaper, and private motor traffic would increase enormously between Britain, France, and the other European countries.

Even with our modern techniques the construction of the Channel Tunnel will be a formidable job; one of the most intricate problems will be that of ventilation, a vital one considering that an incessant stream of motor vehicles, each emitting dangerous gases from its exhaust, will be passing along the tunnel.

As to the actual job of digging, the Russians may be able to help the engineers with their 'mechanical mole'. Soviet scientists made a special time-and-motion study, assisted by X-ray photography, of the burrowing technique of the mole. It was found that the animal burrowed at the rate of 234 feet per hour—more than four hundred and fifty times its own length—in clay, and 361 feet—more than seven hundred times its own length—in black earth.

How does the mole achieve this feat? It digs by working its head and paws to the right and left; the displaced earth falls away on its withers and is pressed against the tunnel walls by the action

of its shoulder blades. The hind legs are used only for its forward movement.

The way in which the mole disposes of the dug-out earth was the most important revelation of the scientists' study. The tunnels dug by the animal were found to have very hard walls—a first-class engineering job. The Russians built first a model of a mechanically operated mole, and then a machine working on the same principle, consisting of a rotating boring head (corresponding to the mole's head and paws), with cutters; two ring-shaped 'expanders' (the mole's shoulders) for ramming the dug-out earth into the sides of the tunnel; and four propelling legs at the rear. The bomb-shaped machine is so big that a driver and an engineer can sit in the nose in a comfortable cabin. To get out of the tunnel the leg movement can be reversed.

Since the first model was built in 1946 the machine has been greatly improved, and a number of them have been at work in the Donbass region. They can, of course, be built big enough for digging the Channel Tunnel, or as smaller, unmanned machines for making drain tunnels. But they cannot work faster than at the rate of about thirty feet an hour—a poor show if compared with the efficient mole.

Let us, for a moment, return to our urban roads. Year after year, the figures for traffic accidents reach new heights, and we ask ourselves: can nothing be done to stop this frightful slaughter on the roads?

Accidents often happen because of technical shortcomings or failures, but much more frequently because of psychological ones. At the Harvard School of Public Health, examinations of people who have been repeatedly involved in accidents ('accident-prone' is the psychological term to describe such types) have shown that they can usually be picked out by psychological tests alone. This applies especially to motorists. 'A man drives as he lives', concluded one of the doctors who carried out these studies.

To put it plainly: accidents do not, as a rule, happen by chance; people who tend to cause them should not be allowed to use lethal weapons—and a motor-vehicle is a lethal weapon. They are a danger to themselves and to their fellow-men.

The statistical figures for motor accidents include those of power-assisted bicycles, which have become such a favourite

branch of motorized transport because of the cheapness and low running costs of the little engines that can be fixed so easily on any bicycle. The British Road Research Laboratory examined the road qualities of power-assisted bicycles and came to the conclusion that they constitute a special danger in the streets. The trouble is that they have only normal bicycle brakes but travel much faster than ordinary bicycles. At a speed of 20 m.p.h. the braking distance is 26–37 feet (a motor-car needs only 21 feet), and as much as 43–94 feet if the road is wet (motor-car—23 feet). In the late 1950's the motor-scooter, or 'moped', began to replace the power-assisted bicycle to some extent; it is a safer vehicle because its brakes and controls are better and it cannot go very fast, but altogether the single-track motorized vehicle in all its forms adds very considerably indeed to the perils of our roads.

We all agree on one point: that 'speed kills'. More pedestrian crossings in the streets of our cities, subways and fly-overs, trafficless shopping centres and playing-streets—they will all help to make walking safer; but nothing will help so much as the self-discipline of motorists. 'The main root of the mischief', said Max Beerbohm as long ago as 1936, 'is that great fetish of ours, Speed.' Unless we discard it and behave like sane, responsible people instead of acting like toddlers with a new toy, there will be no true progress in transport.

II. Ships of Tomorrow

WE CANNOT TELL for sure what the ships of tomorrow will look like; all we know is that they will be as different from those of today as the *Queen Mary* is from the *Cutty Sark*.

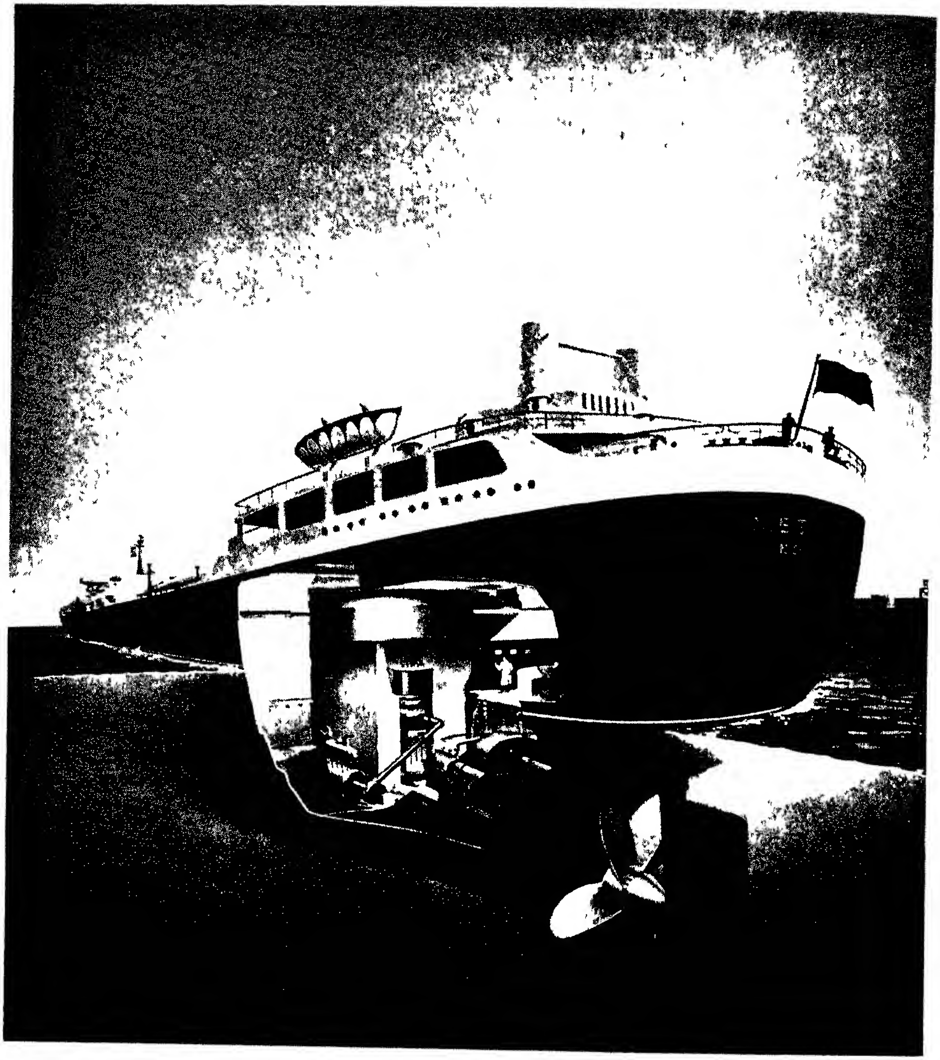
Ships have changed merely in size and power since the screw-propeller was introduced a century ago. Whether they are still driven by coal-fires and steam or by oil and steam or by diesel-engines, their design is more or less the same as it was decades ago. But there are many signs that sea transport is at last entering a new phase. Two developments are forcing the shipbuilders to look for novel paths: the competition of the airliner and the coming of nuclear power. They are interconnected; nuclear power may help the shipowners to meet their formidable rival. In 1954, 40 per cent more travellers crossed the Atlantic by sea than by air; in 1958, there were as many air passengers as sea passengers.

The dust had not yet settled over Hiroshima and Nagasaki when the world was told that one of the most important peaceful uses of nuclear energy would be in shipbuilding. The reason was obvious from the start: on the one hand, a ship would benefit more than any other means of transport from a fuel that does not need to be replenished for a long time; on the other hand, it can easily carry the necessary heavy shielding.

The first nuclear-powered ship, however, was not meant to serve a peaceful purpose; it was the U.S. submarine *Nautilus*, which began its sea trials in 1955, and steamed no less than sixty thousand miles on a single charge of fuel; on that journey, the total amount of fuel consumed weighed about 8 lb. The ship would have needed 10,000 tons of oil if it had been propelled by conventional engines.

In August, 1958, this submarine carried out one of the most outstanding feats in the history of ocean travel: it sailed from the Pacific to the Atlantic by going under the North Pole, thus opening an entirely new sea route between Europe and the Far

12. Britain's automatic train control. *Left* the engine with its 'receiver' passes over one of the 'track inductors'. *Right*. driver's control unit showing the indicator at 'Caution' (See also diagram on p 27)



16. Nuclear-powered tanker. an artist's impression of a 50,000-ton tanker powered by an atomic reactor.

East for nuclear-powered submarine cargo (and perhaps passenger) ships. This route will cut the journey almost by half. Travelling at an average depth of more than 400 feet, the *Nautilus* used the system of so-called inertial navigation (which is also used in guiding ballistic missiles), since astronomical navigation was impossible under the ice and the compass was unreliable owing to the proximity of the magnetic North Pole. The system proved remarkably accurate during the ninety-six hours the ship travelled under the ice. It works with a system of gyroscopes which measure the changing speed of movement of the vessel in relation to two directions fixed at the start; this information is fed into a small 'electronic brain', which provides a continuous record of the ship's position. This system will be of great value in the next phase of transport at sea. After the success of the *Nautilus* an American submarine expert predicted underwater 'tug-trains' and passenger crossings unmarred by seasickness. We shall discuss these revolutionary ideas later in this section.

Although the *Nautilus* and other American submarines of a similar type, which have since been launched, proved that marine propulsion by atomic energy can be most effectual, they also proved that it can be very expensive; reactor, machinery, and body of a nuclear liner or cargo ship will have to be designed carefully to make full use of the advantages of the new mode of propulsion. And that means first of all that a new balance between size, payload, speed, and power must be struck—in other words, it requires a complete reorientation in shipbuilding.

So far, the speeds of conventional ships have been limited by the 'wave-making' resistance of the hull, which acts as a drag, and by the amount of fuel they have to carry; the higher the speed and the longer the run, the greater is the fuel requirement, with a corresponding reduction of the payload. An atom-powered ship can travel at high speed over long distances without having to carry any fuel. But a nuclear reactor is much dearer than an oil-engine, and the protective shielding weighs heavily; a small ship could not afford to carry an economic payload as well. Therefore, the introduction of nuclear energy in shipping tends to encourage the design of larger and faster ships; however, a nuclear-powered ship which spends a lot of its time in harbours, loading and unloading, would be uneconomical.

But there is no reason why we should allow our minds to run in the well-worn groove of regarding the ship and its power unit as a whole. We might gain from separating the two—emulating, as it were, the engine-and-coach system of rail transport. We could build nuclear tugs on the one hand and engineless passenger or cargo ships on the other. These tugs could be in continuous operation, towing liners and freighters at high speed across the sea. The tug would detach itself from the ship on arriving at port, and pick up another vessel at once. Refuelling would be necessary only after six or nine months.

The towed ship could be built much lighter than a liner or cargo boat with heavy machinery; it might be constructed cheaply and economically from prefabricated parts, possibly of plastic material. It could be designed completely streamlined and enclosed, without funnels and other features of a self-propelled ship.

Another new development, so far tried out only for military and luxury purposes, is the hydrofoil boat. It has underwater 'wings' fixed to the hull; as soon as the ship reaches a certain speed, it rises from the water, leaving only the 'wings' in it. A cross-Channel hydrofoil ferry travelling at a speed of sixty knots would carry its passengers from Dover to Calais in less than half an hour; but this type of ship would not be economical if larger than 1,000 tons.

However, instead of rising out of the water our future boat could perhaps go *under* it!

The first submarines were built for military purposes, and until recently shipbuilders scorned the idea of using underwater vessels for peaceful purposes. But why not? Submarine tankers and liners are a logical development, just as logical as that of the stratosphere cruiser in air travel, which avoids the turbulent air in the lower regions of the atmosphere. In fact, a submarine ship gains even more, for it avoids the problems resulting from the difficulty of travelling in two elements, water and air—a difficulty which every conventional ship has to surmount continually: it is disturbed in its course by waves, currents, and winds. The submarine vessel moves in a far quieter sphere; it is safe from storms, waves, and surface drag, and can move with a minimum of resistance. If the *Queen Mary* were built as a submarine liner she might be able to travel at nearly twice her present speed without using more power.

Why, then, have submarine liners not yet been built? Because conventional ship propulsion needs a great deal of air. Nuclear reactors, however, do not; and therefore the whole idea of underwater travel has now become a practical proposition.

A number of very large nuclear-powered, submarine oil tankers, in the region of 80,000–100,000 tons, may be launched in the early 1960's, and some 50,000-ton cargo submarines by 1967; after that, submarine liners. Many experts believe that an era of universal underwater travel and transportation will begin within one or two decades.

A journey across the Atlantic in such a ship will be very different from today's crossing. The torpedo-shaped liner will be completely enclosed, its course being controlled by vertical and horizontal tail fins. Navigation will be entirely by radio beams. There will be no look-outs, only lookers-in at the radar screens, which will be the sole means of discovering other ships, land, obstacles and so on. The passengers may miss the chance of taking a walk on deck, but as the crossing from Southampton to New York will take only forty-eight hours there will be little time to get bored—they will have the usual ship's entertainments and a few more which will have been created by that time.

Are we looking too far ahead? The famous physicist and courageous explorer of the stratosphere and the deep sea, Professor Auguste Piccard, has made an even more far-reaching suggestion.

Professor Piccard's boat—he calls it the 'dolphin'—would look not unlike a whale. The passengers about to board it at the jetty will notice that its glittering 'skin' reacts with tiny movements to every little wave even when the craft is moored.

As soon as the passengers are aboard the doors close hermetically, and the ship sinks fast as it moves forward. There are no windows or portholes; it navigates by automatic pilot. When it has reached its top speed—no less than 190 knots, according to Professor Piccard—the passengers will feel no movement at all. Propulsion can be effected by turbo-jet, pushing the boat forward by the recoil of the hot gases. But what matters is the fact that the dolphin swims exactly like a fish.

The secret of its speed is that it suppresses or counteracts even the slightest eddy around its body. The water divides in front of it and closes up quietly behind it without developing any wake

or whirlpools; in fact the 'closing-up' of the water behind the boat gives it an additional push instead of slowing it down by forming a wake with eddies as in the case of conventional surface ships.

In its initial stage, an eddy can be counteracted with a minimum effort, just as a blade of grass may be sufficient to stop a small lump of snow from growing into an avalanche. Like a fish, the boat has a special mechanism for reacting to the slightest difference of pressure against its 'skin'; within the fraction of a second, the irregular water pressure is counteracted and equalized at the precise point where it occurs. The 'skin' of the ship, made of an elastic rubber-like material, covers its entire body; therefore, it cannot have any portholes. Underneath the skin there are innumerable manometer cells which measure the water pressure and report it to the electronic brain of the boat; the brain feeds its instructions back to the electro-magnetic devices which are also incorporated in the skin and can carry out minute movements to destroy any eddy that may have developed. The result is that the 'dolphin' reduces water resistance to about one-hundredth of that of a conventional craft of comparable size. By travelling under water the boat avoids the problems involved in travelling half in air, half in water. 'The "dolphin" could cross the Atlantic between breakfast and supper,' says Professor Piccard.

These revolutionary submarine ships may still be a long way off, but nuclear propulsion is just round the corner. Surface tankers in the 100,000-ton range are already being designed with nuclear reactors, though they will otherwise look like conventional craft, or very nearly so; they will be used for the 13,000-mile journey from the Persian Gulf to Britain via the Cape of Good Hope—they would be too large for the Suez Canal, and the length of the journey makes nuclear ship propulsion economical. Japan, too, is developing a nuclear tanker for the long run from the Middle East, as well as a 30,000-ton submarine tanker.

Meanwhile, designers will learn a good deal from experiences with America's first nuclear-powered combined passenger and cargo ship, the *N.S.* (Nuclear Ship) *Savannah* (to be launched in 1960) and from America's and Britain's nuclear submarines; perhaps also from Russia's atomic icebreaker, the *Lenin*, which was launched in December, 1957.

This ship is intended for the North Siberian route and is therefore

extremely powerful and sturdy; although her displacement is only 16,000 tons, her nuclear-powered steam turbines will develop 44,000 h.p., which is about fifteen times more than a conventional freighter of the same size develops. For an icebreaker which has to operate in the Arctic for a whole season, nuclear energy has very great advantages; no other type of ship could carry enough fuel to see her through the whole season, and refuelling of conventionally powered icebreakers is a difficult and costly operation. From that point of view the construction cost of the reactor is of minor importance.

Still, until we have more experience with the operation of nuclear power in marine transport we shall have to make do with conventional machinery. The gas-turbine has come to the fore since the end of the war—its development was a 'by-product' of the jet engine for aircraft. To be sure, there has been some disappointment; it looked at first as though that simple and efficient prime mover might prove to be the ideal engine for all but the largest ships. A great deal of research work was carried out, but a few disadvantages of the gas-turbine baffled the shipbuilders and engineers. There is, first of all, the fuel consumption, which is high; secondly, it turned out that the temperature at which the engine can be operated is not as high as was expected, which means that it cannot work as economically as the engineers hoped it would. In the air, however, it has proved its worth brilliantly.

Only a small number of ships have been fitted with gas-turbines as propulsion units, but a new use for them has now been found—as additional power generators for the ship's electricity supply. The cargo ship *Weybridge*, which was completed on the Clyde in 1958, uses the gas-turbine for this purpose. It is a diesel-engined ship with an auxiliary boiler which is heated from the exhaust of the main engine when this is running; but in harbour the main engine is not in operation. The boiler is then heated by the exhaust from the gas-turbine, which supplies the ship with electricity. This seems a sensible solution which may, after all, lead to a general fitting of gas-turbines in merchant ships, though not as main engines.

Among the many inventions made by Sir Henry Bessemer, the man who developed the first efficient steel-making process, was a channel steamer that was supposed to prevent seasickness: its

saloon was suspended on pivots so that it would remain stable while the ship itself was being tossed about by the waves. Bessemer lost a good deal of money and much of his reputation as an inventor when the ship failed to come up to his expectations; in fact, she rolled worse than any ordinary steamer, and the hapless passengers were more seasick than ever before.

Since Bessemer's days, the public and the shipping experts have been rather suspicious of inventors' claims to have discovered a new way to keep ships from rolling. The man who eventually succeeded did so only after overcoming much resistance and prejudice.

His name was Dr J. F. Allan, and he died at sea in 1957, a short while after his invention had been adopted by the largest ships in the world, the Cunard 'Queen' liners. Dr Allan had been on the staff of a leading British shipbuilding company for a quarter of a century, and worked for the last decade of his life as superintendent of the Ship Division at the National Physical Laboratory. He was also the inventor of the 'hydrofoil' boat which we have already described, and his experiments with this during the second World War prompted him to seek a solution for the problem of rolling. The Japanese had tried out a system of using stabilizing fins, which could be tilted, in 1936, but it was a failure because, as Dr Allan discovered, the tilting mechanism was too slow to react to the movement of the waves. He developed a better system.

Looking down from the dry dock it seems incredible that the two small fins projecting from each side of the mighty hull of the *Queen Mary* and the *Queen Elizabeth* well below the water line should be able to stop the giant liner from rolling in the heavy Atlantic seas. Yet these fins really do the trick although they are only 11 feet 4 inches long and 7 feet 6 inches wide. As long as there is no roll they remain half inside the hull and in a horizontal position, but as soon as the waves try to lift the ship out of the horizontal the fins are fully extended and tilted like the ailerons of an aircraft, one in one direction and the other in the opposite direction, counteracting the force of the waves. Within three seconds these stabilizers can move their full range of 40 degrees. They are able to reduce a 30-degree roll to 3 degrees or less within one and a half rolls, or about 30 seconds. 'If we ever get any bad weather in the future', said the master of the *Queen Mary*

after the first trip with the stabilizers, 'the passengers won't even know they're at sea.'

The competition of the trans-oceanic airliner must be met by the shipowners by reducing the fares, and many believe that the best way is to build very large ships. Four giant passenger liners, half as big again as the 'Queens', will be launched in the early 1960's by a Dutch company. Each will carry 9,000 passengers (*Queen Elizabeth:* 2,300 passengers); the oil-fired engines will drive four screws. The trip across the Atlantic—there is only a single class—will cost £55 (£75 tourist class in the Queen liners), meals not included (there will be medium-priced snack bars on board).

Another important point that weighs heavily with the traveller and tourist is reliability, and here electronic devices have established themselves firmly on the captain's bridge. Just as wireless telegraphy became a matter of course fifty years ago, radar and similar electronic aids to navigation are now a 'must' at sea. On the Atlantic run, liners can now get an accurate 'position-fix' by these methods alone, which set a kind of radio grid along their route. And there are even more marvels to come once the improved radar system, which is now reserved for military purposes, is released for the merchant navy. We shall discuss its possibilities in the next chapter.

Passengers travelling to the Middle East may become acquainted with a new economy device which will reduce the cost of transporting oil to Europe. They may see strange plastic sheets lying on deck. Somewhere in the Persian Gulf these sheets will be unfolded and turn out to be large, sausage-shaped barges into which oil is filled from the refineries; when the ship turns round on its way home these barges are towed behind. Made of rubber reinforced with nylon (tough enough to resist puncture by swordfish) they can hold some thousands of tons of oil. This will probably be the cheapest method of supplying Western Europe with the vital liquid.

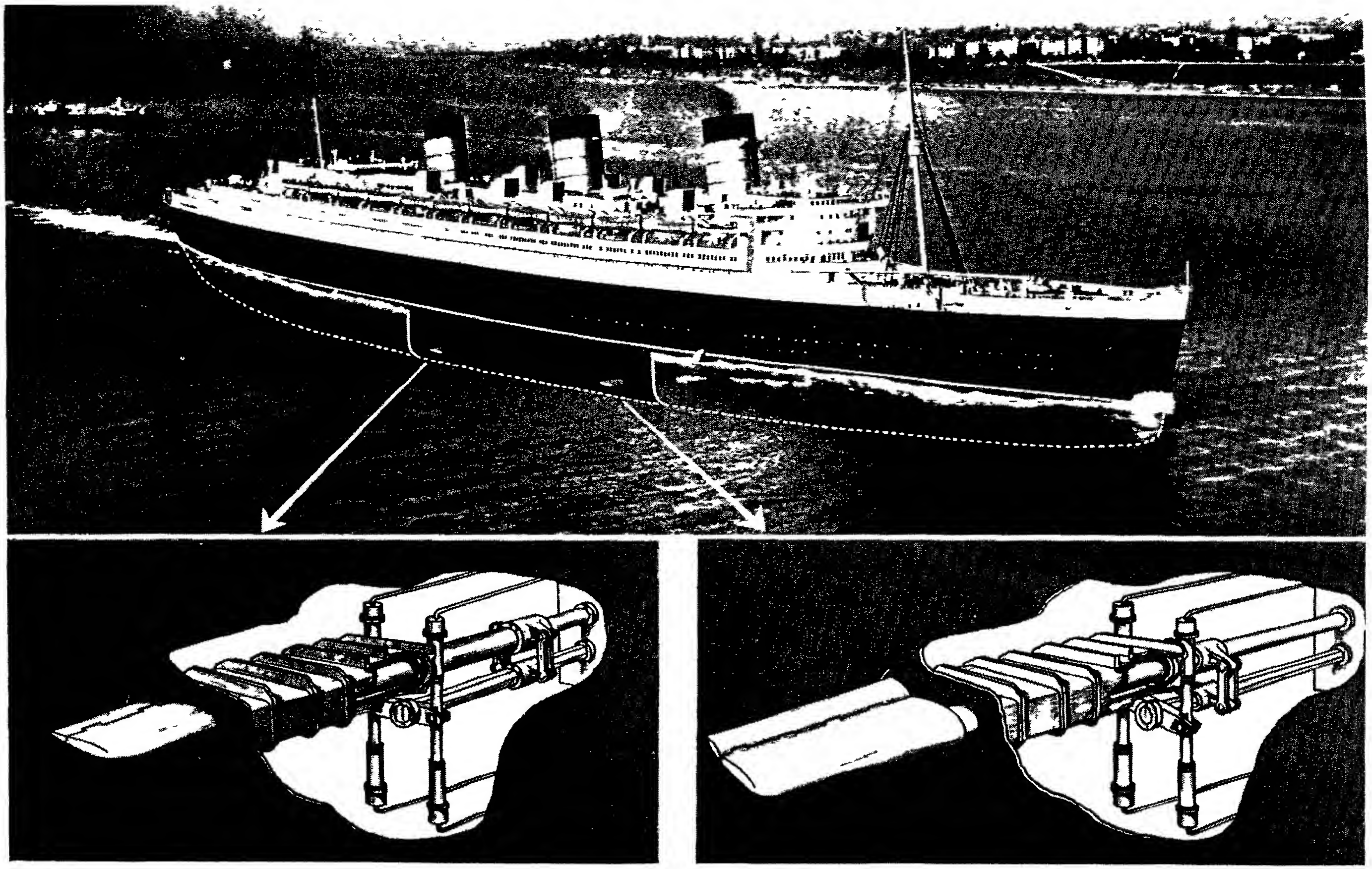
III. How Shall We Fly?

EVERY THREE OR FOUR SECONDS, somewhere on earth a passenger aircraft takes off from its runway at one of 3,500 airfields and airports. At London Airport, nearly fifty aircraft land or take off at peak hours; three and a half million passengers (and their luggage) are handled annually. These figures are steadily increasing, and air traffic control is becoming more difficult as aircraft grow faster and larger. The big jet airliners which have made their appearance on the world's airfields have brought a new set of problems with them. Their speed is much greater than that of other types, especially their landing speed, and their fuel consumption is very high. They have forced a revision of the whole system of airways and air traffic control.

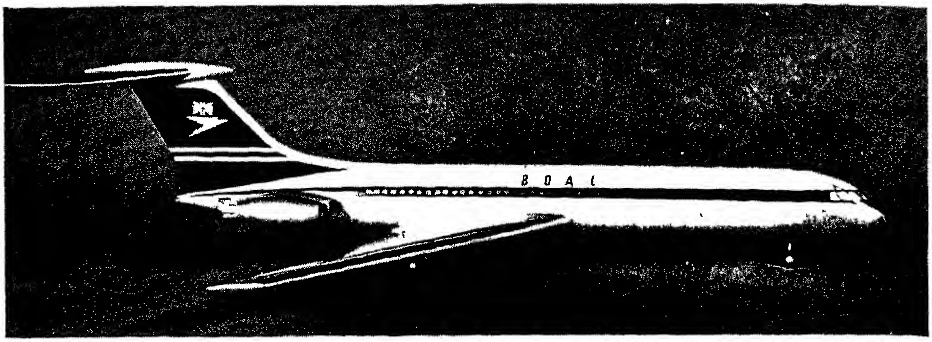
We may expect about two hundred jet airliners to be operating on the main routes by 1962. This means longer and stronger runways, better meteorological reports, improved navigational aids, and stricter airway control, especially in landing operations. The whole pace of air travel will quicken considerably.

One of the major problems of the jet age, however, is the *reduction* of speed. The safe landing of an aircraft depends on its low speed at touch-down. Every aeroplane has a minimum velocity, the so-called stalling speed, below which it cannot remain in the air; and the greater its top speed the higher is also its stalling speed, which means that a fast jet airliner lands fast. A propeller-driven machine can reverse its propellers to shorten its run on landing; correspondingly, jet airliners will have to be equipped with jet-reversing devices for braking.

British, French, and American engineers have been developing such 'thrust reversers' or 'thrust spoilers', which operate either by swinging one or two half-cylindrical shells across the jet nozzle so that the jet stream is deflected by them, or by closing the jet nozzle while opening slits in the sides of the jet pipe, through which the jet forces its way out sideways. Some military aircraft have

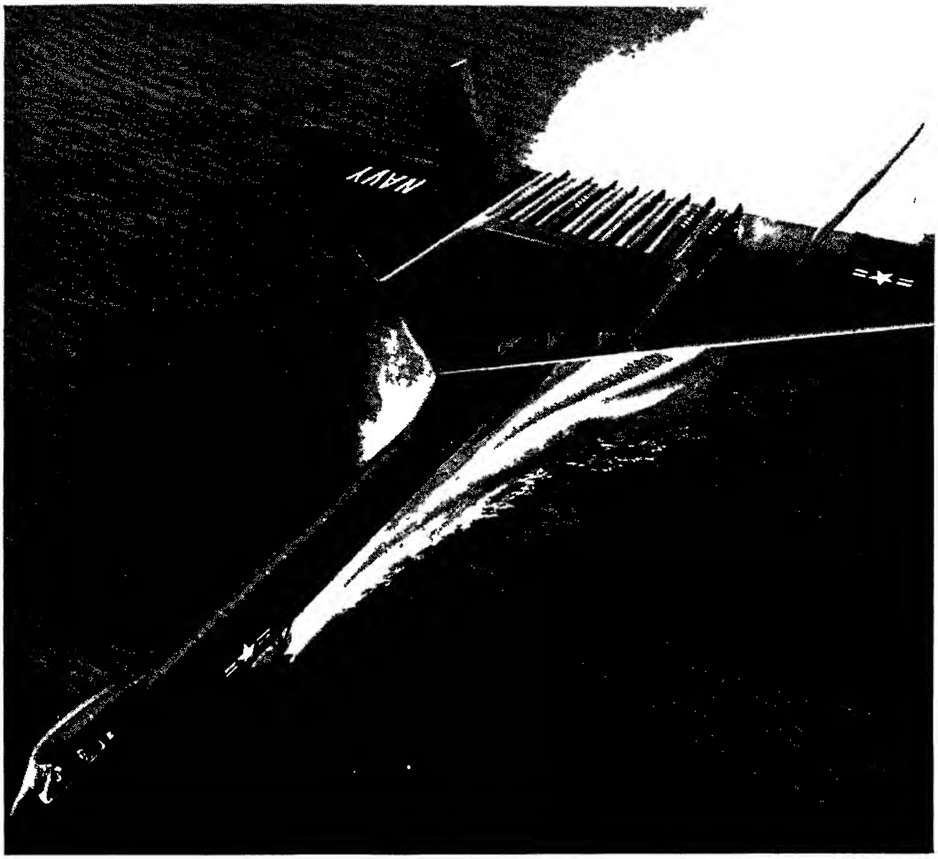


17 The *Queen Mary* with its stabilizers. The diagram on the left shows how the fin is retracted into the hull, the one on the right shows the fin fully extended The hull is cut away to show the operating gear.

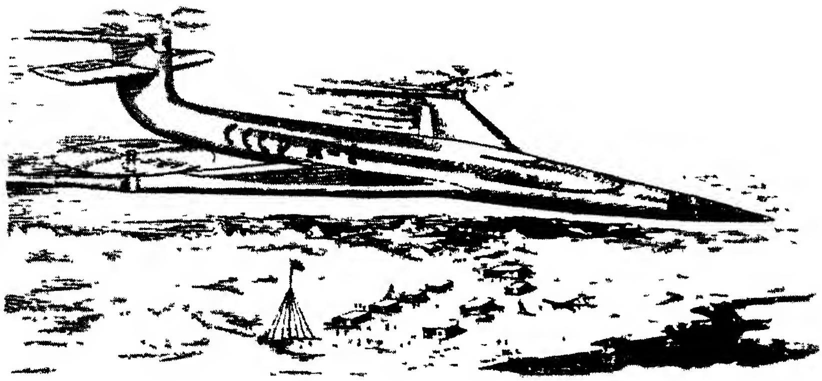


18. A model of the VC-10 jet airliner, due to begin operating in 1963.

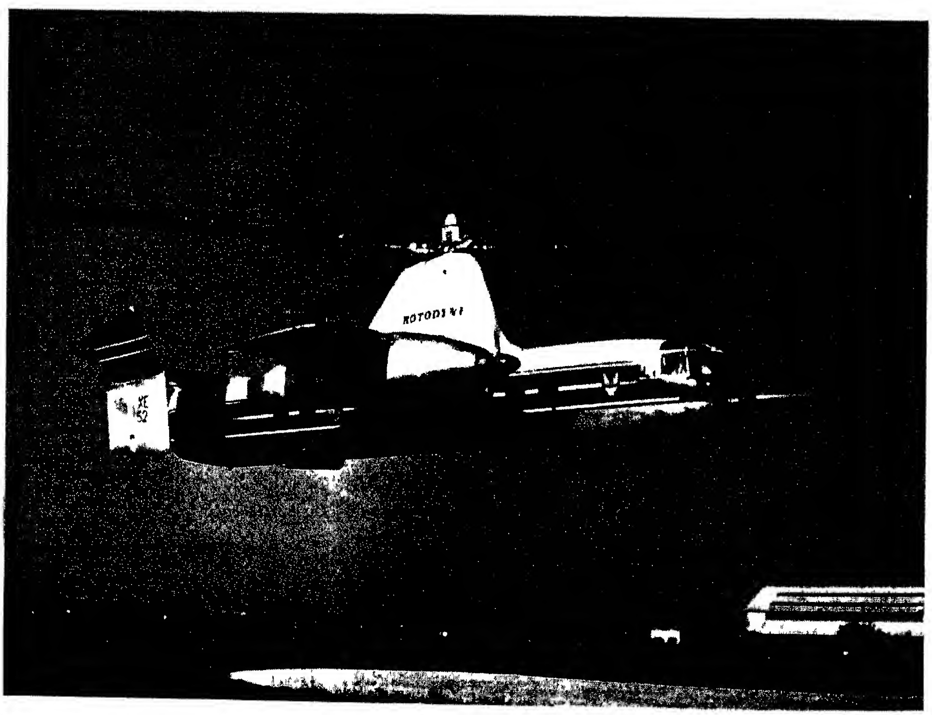
19 The ramjet—or 'flying stove-pipe', as it is sometimes called. It is as simple as its nickname suggests and may have a great future in high-speed, high-altitude air transport.



20. An atom-powered jet bomber under development by the United States.



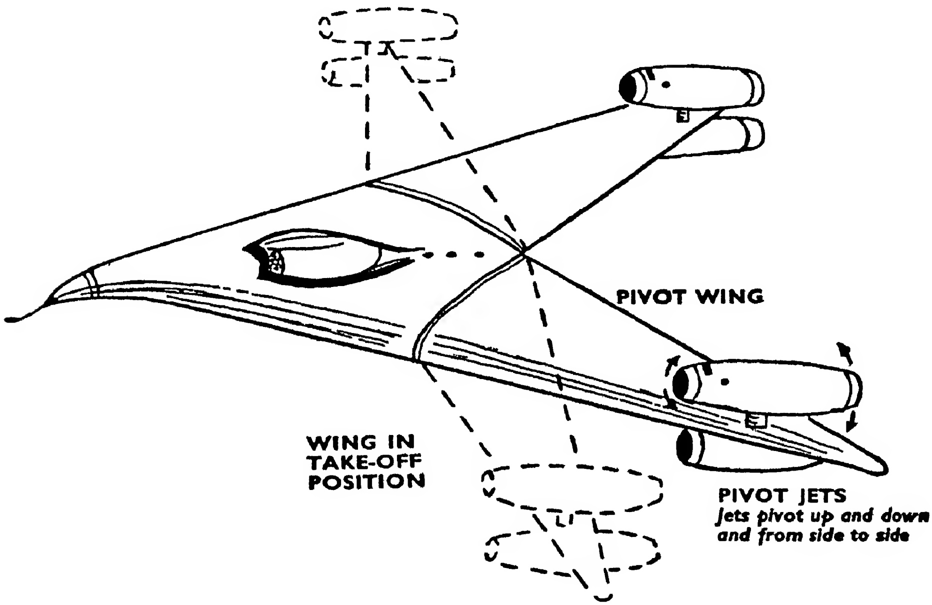
21. A Russian artist's impression of the 'Convertiplane', which would establish an air link with an Antarctic Soviet colony.



22. Britain's 'Fairey Rotodyne' airplane, combining the essential features of a turboprop airliner and a helicopter.

been equipped with an alternative nozzle facing in the opposite direction.

Further airliner designs may, however, follow the lines of a revolutionary bomber created—at least as a blueprint—by the British scientist, Dr Barnes Wallis. His 'Swallow' is designed to fold its wings like a bird, they are straight for take-off and landing, but swept back for flight up to speeds of 1,800 m.p.h., giving the



aircraft the shape of a paper dart. This would eliminate the need for an excessively long runway by reducing the landing speed considerably. The machine has no ailerons, flaps, or tailplane; it is controlled by moving its four jet engines, which are pivoted on mountings above and below the wing tips, in any direction; they can thus also act as brakes on landing. An airliner of this advanced type could cross the Atlantic in 2½ hours. However, conservative experts believe that the London–New York run may still take four or five hours in the late 1960's, and that airliners will take off from ramps with the help of multiple small jets, which will also brake the run of the aircraft when landing.

Manned flight has seen the most spectacular advance in technical history. When the Wright brothers made their first

ascent in a heavier-than-air machine in 1903 they covered 120 feet in 12 seconds—a man's slow running speed. In 1905 they flew at 38 m.p.h. Twenty years later came the first major advance; an American General reached 247 m.p.h., to be followed, in 1931, by a British Flight-Lieutenant who made 408 m.p.h. in a Rolls-Royce Supermarine. By the outbreak of the second World War, the record was 468 m.p.h.; six years later, 606 m.p.h. Within the next twelve years, the speed of manned flight more than doubled, reaching a new record level when the British-built Fairey FD2 flew 1,132 m.p.h. in 1956. Two years later, an American Lockheed Starfighter reached 1,404 m.p.h., and a Bell X.2 rocket plane travelled at 2,260 m.p.h., but the pilot was killed. The age of the supersonic aircraft had begun.

Sound travels at a velocity of 760 m.p.h. at sea level, and at one time many experts believed that it would be impossible to fly at greater speeds because the air would simply refuse to budge, and the aircraft would be shattered to pieces when running against what was called the 'sound barrier'. But there was no barrier, although the drag to which an aircraft is submitted goes up steeply when the speed of sound—'Mach 1'—is approached; beyond it, however, the drag curve 'flattens out', and the aircraft needs relatively little more thrust to reach speeds of 1,000 m.p.h. and more.

Speed records achieved with military aircraft are one thing, flying an airliner at economical cost is another. The British Comet, the French Caravelle, the American DC-8 and Boeing 707, and the Russian Tu-104 and Tu-110—to mention only some of the world's leading jet airliners—travel well below the speed of sound. But the experts agree that sooner or later the supersonic airliner will make its appearance once the design and fuel consumption problems have been solved. There are two schools of thought; one believes that the relatively modest Mach number 1.2, which means a speed of 800 m.p.h. at cruising altitude, would be the limit at which civil air transport could operate economically, while the other puts the 'ceiling' of speed beyond Mach 2, which represents about 1,300 m.p.h. at an altitude of 40,000 feet.

We have mentioned some of the possible designs of supersonic airliners, the folding-wing type with pivoted jets and the type which has multiple jets for vertical lift and landing—acting on the 'flying bedstead' principle—as well as powerful jet engines for

forward thrust. Both types need very careful wing design to withstand the shock waves of supersonic flight and the drag of compressed air. But the most formidable problem to be overcome is that of the 'heat barrier'.

Any object moving at speed through air gets hot because of the friction of the surrounding air against the air of a thin 'boundary layer', carried along with the moving surfaces. At Mach 3, three times the speed of sound, the temperature would rise by about 400 degrees centigrade; this would be sufficient to melt glass within a few minutes. What can be done to prevent the aircraft and its passengers going up in flames?

First, new alloys with high heat resistance must be used in construction. Titanium alloys have proved to be especially good for this purpose, but even they are subjected to 'creep'—slow distortion—at high speeds. Aluminium alloys are useless; they cannot stand up to a speed of Mach 2 for more than a few minutes. But ceramics can; a 2,000 m.p.h. British fighter has, therefore, been designed from pottery and steel.

Second, some device to make the surfaces of the aircraft 'sweat' may help to keep the temperature down. This can be done by covering it with a porous 'skin' and squirting some fluid through the pores. With this method, one of the most awkward problems, that of irregular distribution of friction heat, may be overcome.

However, there is no universal cure yet for the overheating of aircraft travelling for hours through the atmosphere at twice or three times the speed of sound. But there is one way of avoiding the heat barrier altogether—that of getting out of the atmosphere. An aircraft reaching the speed of Mach 10 just outside the atmosphere could 'coast' for about 1,200 miles after shutting off its engines. Some aeronautical experts believe that long-distance flights will eventually be made by means of long 'hops' outside the stratosphere, making the airliner glide for a few hundred miles at a time.

At speeds not much in excess of Mach 1, an air-cooling system has shown itself to be quite effective: air from the engine or from an extra intake is cooled either by a radiator or by a liquid refrigerant—that is, the system of a motor-car or of a refrigerator may be used to cool the aircraft structure. The fuel of the aircraft itself may also act as a coolant, provided that it does not get so hot

as to vaporize while still in the fuel lines. An American suggestion, however, goes so far as to suggest the use of liquid hydrogen—it might not have to be burnt up at all in the engine, but would be able to drive the aircraft merely by being discharged as a jet in vaporized form; and it would provide an excellent coolant.

A great deal of research and experimental work will have to be done before we can say with confidence that the 'heat barrier' will prove to be no more of an obstacle than the 'sound barrier' has been to the progress of flying.

Although the French Caravelle, with its rear-mounted Rolls-Royce engines, has been flying since 1955, the age of jet airliner transport began in earnest only in the winter of 1958–59 when Britain's Comet IV and America's Boeing 707 and DC-8 started their regular transatlantic flights. At the same time, Russia's Tu-104 and Tu-110 entered into competition with the western airliners.

We may call this the first phase in jet transport. Most short-flight routes are still being served by piston-engined and turboprop machines, with the latter—a British invention—gradually taking over from the former. (In the turboprop engine the expanding gases of the burnt fuel act on the blades of a turbine on whose axle the propeller is mounted.) By 1963, however, this picture will undergo a radical change when the 'second phase' of jet transport begins.

The British VC-10, built by Vickers, will then come into operation, a very fast and extremely comfortable four-jet airliner carrying up to 152 passengers on long-range flights, including the tropical routes. It will be the first large jet airliner capable of operating from high altitude airports in hot weather (where the thinness of the air is quite a problem) without being limited in payload—a very important point on the African and Far Eastern runs.

At the same time, the first British jet aircraft for short and medium-range flights—up to 1,500 miles—will also come into service. It is the de Havilland D.H.121, with a cruising speed of 600 m.p.h. and seats for seventy to a hundred passengers. Few piston-engined machines will still be in the air in the early 1960's, and from then on a steady decline in the number of turboprop aircraft may be expected save on very short runs of less than 500 miles.

The aircraft designers are, of course, looking even further ahead. Some visualize enormous, twin-bodied machines with spacious quarters for the passengers in a single wing between the two cigar-shaped torsos. Others believe that aircraft looking like seagulls with folded wings would increase aerodynamic efficiency at speeds up to five times that of sound—more than 3,000 m.p.h. —provided that we can find materials for aircraft surfaces which could operate for long periods at temperatures of 600 degrees centigrade. In the more distant future, airliners might virtually become guided missiles which will be lifted out of the earth's atmosphere by rocket motors and glide most of the journey at speeds up to 12,000 m.p.h. A journey from London to Sydney would then take no more than an hour!

An Austrian designer, Dr Helmut von Zborowski, has come forward with what he calls a coleopter, with circular wing around the aircraft body; it can start and land almost vertically and go into a horizontal position only when it has reached its cruising altitude. The passengers would have to be given swivel seats so that they do not lie on their backs or fall on their faces during vertical flight. The coleopter is powered by ramjet engines (see next page); a prototype, built in France, was tested in 1959.

The Russians are emerging more and more as excellent and imaginative aeronautical designers. One of their short-range propeller machines, the Bee, can take off from any unprepared piece of land; another aircraft for vertical take-off is catapulted into the air by a rocket attached to its tail; at cruising height the rocket is dropped. A Russian rocket-liner is being developed; it is designed to carry passengers at between 9,000 and 10,000 m.p.h., and to take off vertically but sprout large wings so that it can land as a conventional aircraft.

Rockets as propulsion units for airliners have so far been neglected for their particular advantages begin to show only when they operate outside the atmosphere of the earth—they are therefore the only suitable prime movers in space flight. But as air transport reaches higher and higher into the thinner layers of the atmosphere the designers are taking another look at the rocket. The reason why it does not need air is that it carries within all the chemicals which are necessary for the generation of the gas which drives it forward.

The American research aircraft, X-15, the first of which was

built in 1958, has been given the task of exploring the possibilities of manned rocket flight up to altitudes of a hundred miles and perhaps more, and the problems involved in returning to earth in controlled flight. From such heights, space flight will be only a matter of additional 'boost'; at 12,000 m.p.h. the manned rocket aircraft could be put into an orbit around the earth, and another 'boost' might take it on its way to the moon.

For a long time to come, however, air transport on earth need not operate at altitudes beyond, say, twenty miles; and jet propulsion will be capable of meeting all foreseeable requirements. Jet engines are 'air-breathing'. The turbojet (not to be confused with the turboprop system in which gas-turbines are used to drive conventional propellers) sucks in air, compresses it, and mixes it with the fuel in a combustion chamber; the expanding gas drives a gas-turbine and rushes out at the rear, thus propelling the aircraft. Like the rocket, the jet-engine relies on the 'recoil' effect based on Newton's third law of motion: that to every action there is an equal and opposite reaction.

Halfway between the turbojet and the rocket there is a prime mover which has somewhat lagged behind in development, but to which the aircraft designers are now giving more attention—the ramjet, or, as the Americans have nicknamed it, the 'flying stovepipe'. Like the turbojet, but unlike the rocket, it is an air-breathing engine; like both it achieves propulsion by pushing a powerful stream of gas backwards. But in order to burn the fuel effectively the air must be compressed. The ramjet, being a much simpler device than the turbojet, has no compressor (in fact, it has no moving parts at all); it must, therefore, rely on its own very rapid forward movement to achieve the compression of the scooped-up air before it can start operating. This means that a ramjet aircraft needs an auxiliary engine which accelerates it to nearly the speed of sound: only then will the air pressure be great enough for the ramjet.

The main disadvantage of the ramjet is thus that it will not begin to work when it is stationary, and that it needs another prime mover as a 'starter'. Another disadvantage is that it is difficult to control, and that its operation is subjected to the shock waves which tend to form at the scoop. But there are also very great advantages. Having no turbine or other moving parts which can

work only at limited temperatures, the ramjet can stand much greater heat—about 2,000 degrees centigrade; and the higher the temperature of the gas jet, the greater will be the speed.

The obvious use of the ramjet in future air transport will therefore lie in long-distance, high-altitude flying; other forms of propulsion, such as turbojets, will bring the aircraft up to the speed of sound, and then the ramjets will take over in supersonic flight. In the wide speed band between Mach 2.5 and Mach 4 the ramjet offers more thrust for its weight and it burns less fuel than any other prime mover; and it can operate in a much more rarefied atmosphere than a turbojet while its fuel consumption is much less than that of a rocket engine.

An English engineer, C. S. Cockerell, designed the 'Hovercraft', a disc-shaped flying saucer—half wingless aircraft, half flying ship—which travels a few feet above the road or water on a cushion of air, produced by many downward jets of compressed air. It takes advantage of the so-called 'ground effect', often infuriating to pilots: a pad of condensed air which keeps an aircraft a foot or so above the ground before touching down. With a low-powered gas-turbine for forward movement, speeds of 80 m.p.h. could be reached. A prototype was tested on the Solent in 1959.

Nuclear-powered ships have been regarded as a matter of course right from the beginning of the peaceful utilization of atomic energy, but the notion of nuclear-powered aircraft has always aroused a great deal of controversy. Bombers of this type, which have been built with no regard for economy and little regard for safety, are of course a very different proposition from commercial airliners. The layman may be fascinated by the idea of an aircraft which could stay up in the air for three months or more without refuelling. But is there any need for such an airliner?

The use of reactors for aircraft will depend on their weight and the weight of the shielding. In a bomber, the technique of 'split shielding' will serve its purpose: part of the radiation shield is put around the reactor, and another shield around the crew compartment. An airliner, with perhaps a hundred passengers, would need very massive shielding around the reactor, weighing dozens of tons.

Under these circumstances, the use of two reactors in one aircraft seems to be out of the question. Yet how else could one

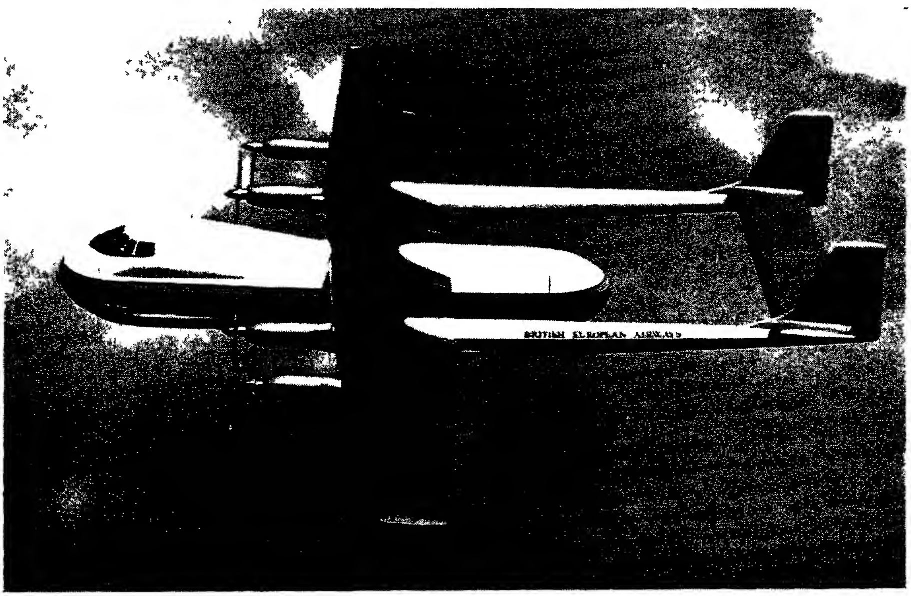
assure the safety of the passengers? If there were only one reactor and it failed or had to be shut down in mid-air, the aircraft would crash inevitably. If the aircraft were made to carry an auxiliary engine—say, a turbojet—to be put into operation in an emergency there would be really no advantage whatsoever in using atomic energy for the main propulsion unit. When one of two or four piston-engines, turboprops or turbojets in an airliner fails it can still make a safe landing; even with three out of four engines out of action this can be done.

Until some miracle material is found which affords complete protection against radiation while weighing next to nothing, the prospects for nuclear airliners seem rather bleak. Perhaps the gravest risk of atomic aircraft would be that a crash might scatter radio-activity over a wide area.

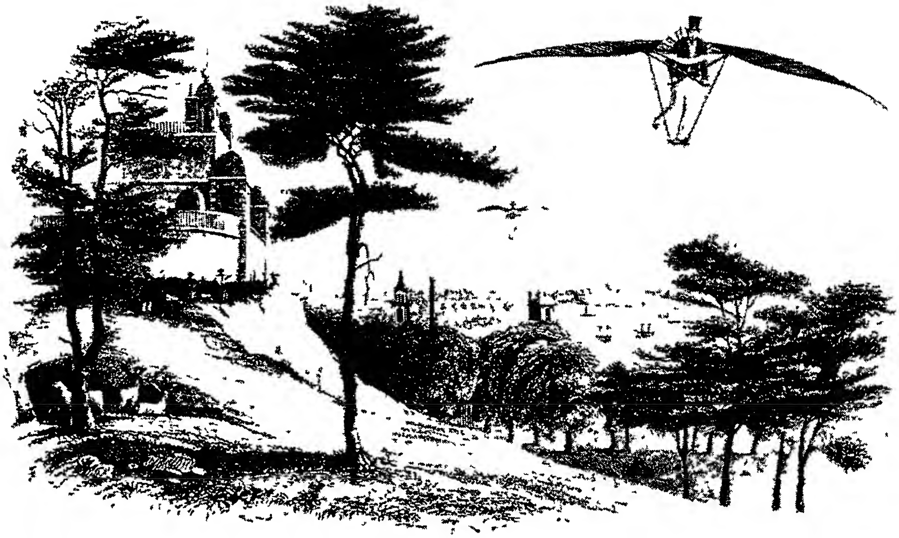
Yet in spite of all these difficulties there may be an application of nuclear energy in air transport: the atomic aerial 'tug'. It is an adaption of the atomic marine tug scheme which we have already discussed, and many of the advantages would be the same. There are two versions of the idea. One is that atom-powered 'tractors', without space for passengers, should cruise from continent to continent in a kind of shuttle service without ever landing except for occasional refuelling and maintenance. Land-based, non-atomic airliners would fly up from the airports, hook up behind the tugs, and shut off their own engines. The tugs would pull them at supersonic speed through the stratosphere to points near their destinations, where the airliners would detach themselves and proceed down to earth. The tug, however, would turn round and hook up with other airliners going in the opposite direction—and so on. In this way, the atom-powered tugs could make full use of their ability to stay aloft during long periods, while the passenger-carrying airliners would not have to carry more fuel than they need for two trips up to the tug and down to the airport. The tug could make its way at constant cruising speed high above the turbulent layers of the atmosphere. Crews on board would work in shifts, and relief crews would be carried up at regular intervals.

The alternative version of this idea is for nuclear-powered, windowless transport aircraft to travel at speeds up to Mach 3 between, say, Europe and America, completing about ten crossings per day, with accommodation for at least a hundred passengers.

23. Gatwick Airport near London, which permits rail and road transport to approach the runways up to 100 yards. This airport design may become typical of future installations in many countries.



24. The Argosy freighter-coach, Britain's revolutionary aircraft for fast transport of goods.



25. Man has always wanted to fly like the birds. An artist's impression of the 'invention' of a muscle-powered aircraft in 1843 the 'Aerial Man' passing Greenwich Observatory.

26. The 'Swan', a muscle-operated hinged-wing aircraft designed by a German engineer and exhibited at the Hanover airshow in 1958.

These are flown up from the airports in 'tenders', which will hitch up with the main aircraft so that the passengers can be transferred through a pressurized gangway. Then the tender detaches itself and returns to its airport. The Atlantic crossing would take no more than a couple of hours, and the passengers would lose little by not being able to look out of the aircraft. At heights above ten miles there is not much to see anyway. Windows would be difficult to build because of the great difference in atmospheric pressure inside and outside, say the American proposers of this plan. The crew would be limited to three or four, apart from the stewards, because navigation and control would be completely automatic. Because of the economy of the whole system, fares could be kept rather low; a single aircraft could transport a thousand passengers across the Atlantic per day, half as many as a present-day large ocean liner. The tenders could be kept small, carrying about twenty-five passengers each, and the main aircraft would pick them up over three or four airports on each side of the Atlantic, so that all available space is used.

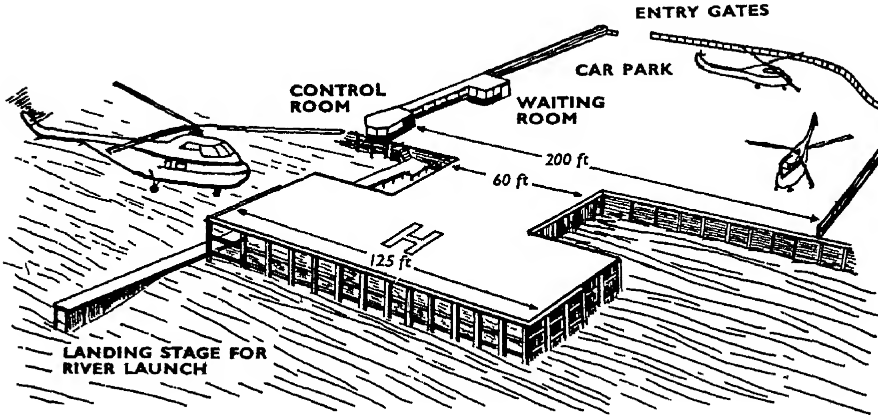
We have been somewhat disappointed by the development of the helicopter. It is an old idea—men had tried to rise in vertical-lift machines by 'screwing' them into the air even before the Wright brothers got their craft off the ground for the first time—but the modern helicopter was developed only during the second World War by the Russian-born American aircraft designer, Igor Sikorsky. We had been expecting to see helicopters everywhere soon, connecting city centre with city centre, and last but not least as a form of personal transport, gradually superseding the motor-car.

Nothing of the kind happened, however; a helicopter connection between Cardiff and Liverpool, inaugurated in 1950, and another one, between London Airport and Waterloo, turned out to be unprofitable and were stopped; a limited service connecting Brussels and some neighbouring Dutch and German towns did not come up to expectations, and three-quarters of the income of New York Airways, which operates helicopters in the New York area, is a subsidy from the U.S. Post Office.

The reason for this is purely commercial. The small, one-rotor helicopter, seating six to twelve, has proved to be the most expensive means of transport at very short ranges. An additional

problem is the noise; wherever plans are made to build heliports, people protest against this intended attack on their ears and nerves.

But the airlines and experts are far from writing the helicopter off or relegating it to the military and other specialized fields. It is on its way to becoming a general means of transport, but it will have to fulfil certain conditions: it must be built much larger, seating forty or fifty passengers; it must have at least two rotors;



London's first Heliport, near Battersea Bridge.

its speed must exceed 150 m.p.h.; and it must be less noisy. Heliports, or rotor stations, might be constructed on elevated sites in the towns, such as railway station roofs, but they must be shielded by baffle walls to reduce the noise; or they might be built underground. London's first heliport, built by Westland Aircraft in 1959, is on the South Bank of the Thames near Battersea Bridge, some distance from any residential areas.

It looks as though the notion of the 'little man's helicopter' will remain a dream, at least for some time to come, but the larger vertical-lift aircraft has probably a bright future. The main feature of the helicopter is, of course, the rotor, which 'screws' the craft into the air and brakes its descent; by altering the axis of the rotor and the pitch of the blades—the angle at which they 'bite' into the air—the aircraft can be steered in all directions and made to rise, descend, or hover in mid-air. Most helicopters also have a small horizontal-axis airscrew at the tail to counteract torque, that is, the tendency of the aircraft to rotate with the rotor.

Increasing the size and power of a helicopter is not an easy matter because the power requirements of the rotor grow very fast with added weight, and torque becomes greater. One solution of the problem is to build helicopters with two or more rotors; another, which has been adopted by most designers, is that of driving the rotor not by transmitting power from an engine in the aircraft body through the rotor shaft, but by small jets on the rotor blade tips. These miniature jet-engines or ramjets require more fuel than if mechanical power transmission were used, but they can achieve higher lifting capacity, and their control is easier.

So far the best design of a large, economic helicopter has been that of the British Fairey Rotodyne, of which a prototype was flown in 1957. It has a large rotor with pressure jets at the blade tips but also short, fixed wings with two conventional turboprop engines. Being rudder-controlled in forward flight it needs no tail propeller. It is, in fact, the first vertical take-off airliner. It rises into the air as a helicopter; at cruising altitude the turboprop engines take over, and drive the aircraft at a speed of about 185 m.p.h. while the rotor is free-wheeling, with its jets extinguished. Before landing they are re-lit, and the rotor makes a vertical descent possible. The Rotodyne seats up to forty-eight passengers and has a range of four hundred miles (distance London–Paris: 225 miles). It is certainly the most advanced means of transport from city centre to city centre. A larger version, carrying sixty-six passengers, will enter service on the B.E.A. routes in the early 1960's.

The Russians have been working on similar lines; their 'convertiplane', to be built in the 1960's, has on each wing a propeller whose axis can be altered from the horizontal to the vertical for ascent and descent, and a third propeller on top of the elevated tail. This aircraft might be equipped with a nuclear reactor, at least experimentally.

French designers have achieved something like near-vertical take-off with their Bréguet 940 for short-range inter-city transport; it has fixed wings over which air can be blown by the jet engine. This gives it nearly direct lift, with no more runway requirements than fifty yards at full load. Dutch designers, on the other hand, have demonstrated their very small Kolibrie, a helicopter with

blade-tip jets. Its speed is not much greater than 60 m.p.h., and it would cost something like £7,500 in serial production. This is perhaps the nearest thing to the family helicopter we have yet seen.

Travelling by air for business or pleasure has become a matter of course, but the transport of goods by aircraft is still in its beginnings. The reason is that the public as well as the airline operators still regard the conveyance of passengers, and perhaps of mail, as their chief business, and the transport of goods as a luxury. Freighter aircraft have been few and far between on the world's air routes.

The appearance of the first turboprop freighter aircraft, the British four-engined Argosy Freightercoach, in 1958, has started a new development. With its simple but robust structure, its single big doors at each end, its payload capacity of over 25,000 pounds and its speed of nearly 300 m.p.h., this aircraft has been specially designed for the exclusive transport of cargoes over medium distances, while previously most air freight had been carried along with passengers on scheduled flights. Its great advantage is a quick 'turnround'—it can land, unload, load, and take off again within twenty minutes, and it can operate from small airfields.

In Europe, where surface transport is well developed, air freight may not assume any major importance in the near future. But in the less developed countries and continents the air freighter will open completely new trade routes, and help to stimulate the rapid growth of prosperity. Railways and ports are much more expensive, and take much longer to build, than runways. The flying freighter may well turn out to be one of the greatest instruments in extending civilization to those areas of the world which have never known it.

The air routes between Western Europe and North America on the one hand and Western Europe and the Middle East on the other are already comparatively well developed for freight flying, and the Dutch KLM derives as much as 20 per cent of its annual revenue from cargo operations in these areas. Other airlines have been slow to follow in making a substantial part of their total aircraft space available for goods; they feel that prospective customers will be put off by the high cost of air freight.

Only an all-cargo network operating on the same lines as the passenger services, planned to reduce costs to a minimum, can raise cargo flying from its position as the Cinderella of the air.

Long-haul freight-only aircraft with a range of about 4,000 miles and a payload of 35,000–45,000 pounds, which would permit economy of operation and appeal to manufacturers and traders by its low cost and reliability, may be the next step.

At the German Air Exhibition in Hanover in 1958, a curious craft aroused much interest—the *Schwan*, or Swan, a flap-wing aeroplane built by a Lufthansa engineer and backed by a roadmaking firm. The *Schwan* was the latest offering from an old-established school of aeronautical thought which believes that the proper way to fly is that of the birds. Its wings, each 22 feet long, were hinged so that two thirds of their length could be pulled downwards by a 4 h.p. diesel-engine; strong rubber bands would pull them up again. The inventor believed that he could reach a speed of 50 m.p.h. with his flap-wing machine if only the Civil Aviation authorities would give him permission to try it out. 'The Russians stole my plans in 1945, and have built 15-seater flap-wing aircraft with them', he declared.

The Russians have indeed experimented with this type of plane, though they were probably relying on designs by their own engineers. They went even further than the German inventor by trying to build machines powered by human muscles alone. Back in 1952, they constructed a flapping-wing glider, the *Kashuk*, with a wing span of 55 feet. The wings were hinged and connected to an adjustable air spring. When in the air, the 'pilot'—if that is the right term—could flap them up and down at variable rates according to wind conditions, or lock them for fixed-wing gliding.

The strange bird, or unpowered ornithopter by its technical name, was so constructed that the wings, when lifting under load, were compressing air in a cylinder, which would cause the wings to make their return stroke downwards. We do not know whether the *Kashuk* has solved the problem of stability in the air, which a bird solves instinctively; in a fixed-wing aircraft, elevators, ailerons, and rudder accomplish the necessary variations of pressure at particular points of the aircraft body. Have the Russian flyers managed to escape the tragic fate of those legendary flap-wing airmen of Greek mythology, Daedalus and Icarus?

The idea of flight by manpower has never ceased to excite the imagination of inventors. In our age, British engineers at the College of Aeronautics, Cranfield, have in fact gone into the

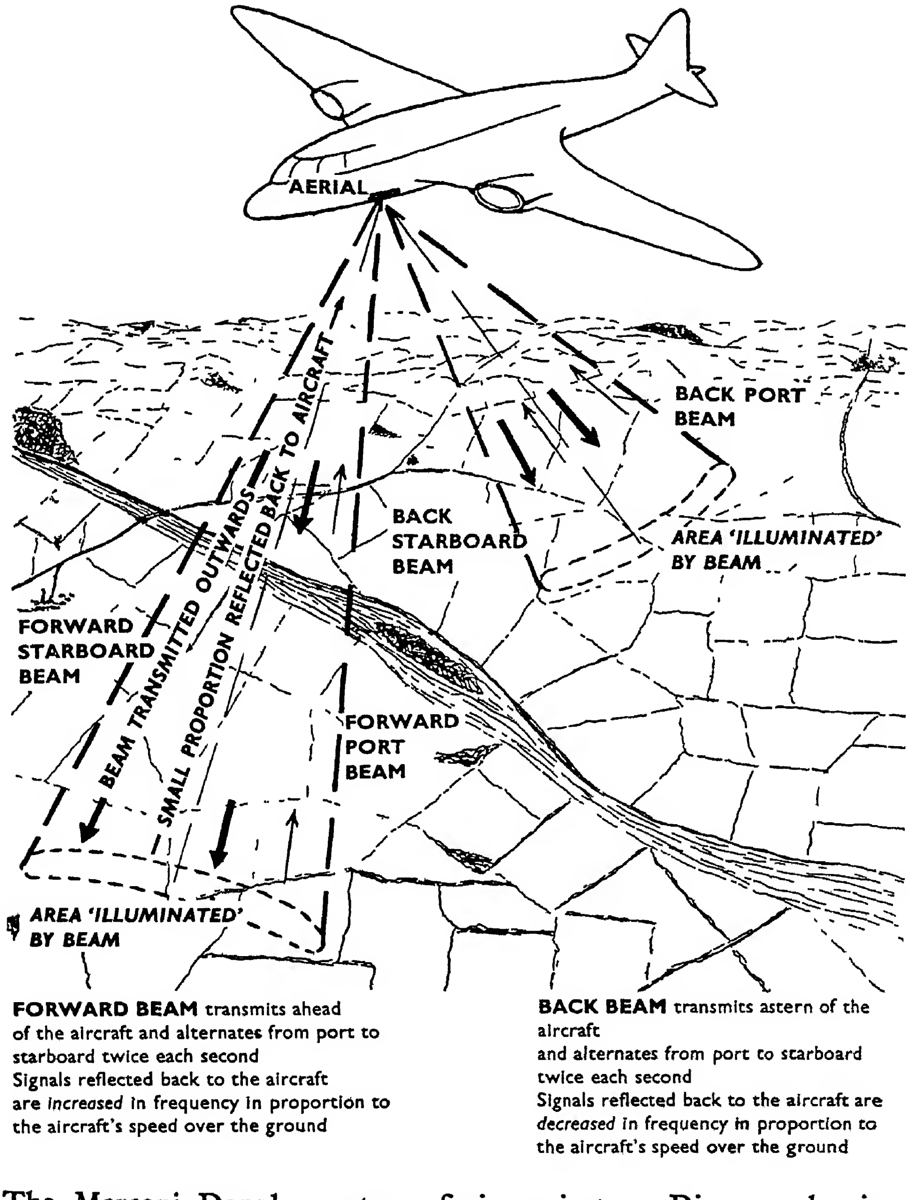
problems involved, using the tools of modern research. Today we know so much more about how birds fly, and soon we may indeed succeed in building such a machine, making the age-old dream of individual flight come true after all—perhaps coinciding with Man's first trip to the moon.

During the second World War, a number of electronic aids to air navigation made their first appearance, most of them based on radar technique. They are an absolute necessity in the congested air traffic lanes of Europe and America, and they aim at turning the business of piloting airliners into a completely foolproof matter.

There is a bewildering variety of them—VOR, DME, DECCA, DOPPLER, DECTRA, DELRAC, ASMI, ACR, TACAN, and many others, and there is a good deal of national and commercial competition to get one or the other system adopted by the individual airline companies. DECCA, British, and VOR, American, are short-range systems with ground stations sending out radio beams which tell the navigator where he happens to be and what course he must take. DECTRA is a development of the DECCA system, especially adapted for the Atlantic run; it uses a 'master' and a 'slave' transmitter at each end of the route to lay an invisible three-dimensional pattern which tells the aircraft navigator his position with a margin of error of no more than ten miles.

The DOPPLER system, developed by Marconi and the Radio Corporation of America, needs no ground stations; an electromagnetic beam from the aircraft bounces back from the ground over which it flies, and the resulting difference in wave frequency is measured automatically to give the navigator an accurate indication of the speed of the aircraft—which is very difficult to assess by other means since the wind velocity complicates matters. This system provides, at the same time, information about the drift angle of the aircraft so that the pilot can maintain his course with accuracy.

With fast jet airliners crowding the airports and airways the most intensive flight control is of vital importance for the safety of the crews and passengers—and of the people who live underneath the aerial traffic lanes. The incessant increase in air transport, which is estimated to reach a world total of 300 million passengers per year by 1970, proceeds faster than the development and installation of new navigational equipment (which must first be



The Marconi Doppler system of air navigation. Diagram showing general principles.

authorized by the International Civil Aviation Organization) and the training of the aircrews in its use. By 1963, London Airport will have caught up with the flow of air traffic in its own area. The network of long-range and short-range radar stations will be extended and electronic computers installed to store and disseminate information at the control centres, and there is a strong tendency towards complete automation of landing.

This could be achieved by the system called B.L.E.U. (Blind Landing Experimental Unit), developed by the Royal Aircraft Establishment, Bedford. It can bring an aircraft safely down without human intervention. A pair of cables is laid down on either side of the runway and fed with electric current, which is recognized by receivers in the aircraft so that it can be automatically navigated to land in the centre of the runway. The height is controlled by means of a radio altimeter to an accuracy of two feet (which is pretty good for a human pilot). A complex system of servo-mechanisms, not unlike those used in factory automation, brings the aircraft down along the chosen flight path for the last 250 feet of its descent. Unfortunately, the world's airlines have so far failed to agree on a common navigational system, which must be able to cope with dense and fast jet traffic. Air safety can never reach its maximum without such an agreement. 'Who would believe in railway safety if there were as many different signalling systems along the line?' is a common remark among airline navigators.

However, many experts are worried about the whole trend towards automatic navigation. They feel that it is a mistake to relieve the human mind of its responsibility. Electronic devices may fail or do foolish things or boggle at some unforeseen obstacles or happenings; a human mind, despite its shortcomings, may be better equipped to deal with an emergency.

It might, therefore, be a good thing to make sure that aircrews are never overworked; on long-distance flights two crews might be taken along to work in shifts. During inquests and investigations following air crashes it has been found that pilots and navigators had been on uninterrupted duty for stretches up to twenty-two hours, and that sixteen hour duty spells are no exceptions. One of the important factors contributing to crew fatigue is the frequent and rapid change of climate; the change from winter to summer, from cold to tropical weather may be only a matter of hours, and is

repeated several times per week. This, say the medical experts, constitutes a severe extra strain on human endurance.

Not only the pilot who has to handle a complicated apparatus is subject to excessive strain but also the stewardesses, or air hostesses as they prefer to be called. A restaurant waiter serves an average of seven guests at a time; an air hostess, between thirty and forty passengers—and she may have to attend to unruly children and people who get airsick in addition to carrying luncheon trays and newspapers, and to adjusting safety belts.

By creating our modern means of transport we have vastly increased the risk to human life. Shipping, next to walking—the oldest form of transport—is now so safe that for years on end there is hardly an accident costing the lives of passengers. On Britain's railways, you may travel for 210 million miles before you get a chance of being killed; it happens only to one out of 10 million passengers.

Things are, however, rather different in air travel. One out of 46,100 passengers of all airlines and chartered 'planes operating from Britain between 1950 and 1954 met with a fatal accident; among passengers carried in scheduled flights only, the fatal accident rate was one in 68,400 passengers. In terms of miles covered the comparison between railways and airliners is not too reassuring either; one air passenger was killed per 31,140,000 passenger miles flown by all airlines (average 1950 to 1954), and one per 43,275,000 passenger miles on scheduled flights. In America, public opinion has demanded special safety measures to prevent collisions between fast-flying machines; the wings of Britain's passenger aircraft are now painted bright red to reduce the risk of such accidents.

The only redeeming feature of this sad piece of statistics is that the situation has improved a great deal since the pre-war period. Between 1936 and 1940, nearly 17 people lost their lives per 100 million passenger miles flown; between 1951 and 1955, only 2.2 people—and the figure may have gone down still further in the meantime.* However, it would be a good thing if the international airline operators agreed to halt for a while their efforts to outdo each other in speed, and competed in the field of safety instead.

* Statistical figures published by the U.K. Ministry of Transport and Civil Aviation.

IV. *Careers in Transport*

MODERN TRANSPORT offers a very wide variety of careers for young people with a technical bent. In the automobile industry, all the manufacturers are running apprenticeship courses for boys who have completed a grammar or secondary technical school education and have the GCE. These 'student apprenticeships' vary in length from three to five years. Four 'O' level subjects are usually required; mathematics and one science subject are compulsory. English, too, is usually regarded as an essential subject. Apprentices attend a technical college on a part-time basis to study for a National Certificate. They are trained in basic engineering at the works, and specialize later in the field that seems most suitable for the individual trainee, such as automobile design or production engineering. The industry is always in need of young men with ability and character who are willing to work and study hard, and there is practically no limit to the positions they can reach in their company.

Craft apprentices, usually selected from secondary modern and technical schools, are accepted at the age of 15 or 16; they will find good opportunities to become well-paid, highly skilled craftsmen.

Traffic engineering—a term coined in America—deals with the planning and geometric design of streets and cross-country roads and with the operation of passenger and goods transport. It is a relatively recent branch of engineering and offers excellent opportunities to the trained specialist. In the U.S.A., courses in traffic engineering are held at many colleges; in Britain, only the University of Durham has a post-graduate school of highway engineering and traffic studies, with a diploma examination, and post-graduate research in these fields is going on at University College, London. Those who want to choose traffic engineering as a career will therefore best embark on civil engineering training, for which there are good opportunities, and specialize later.

The Institution of Civil Engineers holds examinations for prospective members between the ages of 16 and 18; subjects include elementary physics, chemistry, and mechanics, practical and theoretical geometry and trigonometry, arithmetic, algebra, and English. The required standard is that of the GCE. The next hurdle is the professional examination admitting to the associate membership of the Institution, which has to be taken in three parts. Two or more years full-time at an engineering college or a university, or three years of practical training with an approved engineer are required. Civil engineers are in great demand in Britain, especially as the British civil engineering industry builds for a great number of overseas countries as well as for home requirements, and salaries are high.

In railway engineering opportunities are excellent due to the rapid modernization of the permanent way. Diesel engineering is particularly suitable for young people entering this field, and electrical engineering has equally good prospects. British Railways are operating a two-year training scheme enabling apprentices to comply with the requirements for membership of the Institute of Mechanical Engineers or that of Electrical Engineers. British Railways offer permanent, pensionable careers and good chances of promotion.

You do not need a university degree to join the Navy or the Merchant Navy, but in shipbuilding—quaintly called 'naval architecture'—training may take the form of a university 'sandwich' course leading to a B.Sc. at Glasgow or Newcastle, extending over three to four years with a further one or two years to be spent as an apprentice in a shipyard; or the trainee may serve a five-year apprenticeship in a shipyard and go to evening classes at a technical college. At 25, a qualified man becomes eligible for associate membership of the Institution of Naval Architects (which also provides scholarships for students).

There are many ways to qualify as an aeronautical engineer, a flight engineer, or an air-traffic controller. It depends on the young man himself whether he should obtain his technical education at a university or college and then enter the industry for practical training, or reverse the process and become an apprentice at one of the large companies while attending evening classes. Or he may gain his works experience during the first year after leaving school,

then go to a university, and return to the industry for a further period of training. Many firms have apprentice schools and scholarships, and they are eager to retain the young men they have trained. Few industries offer greater opportunities to technically minded young people than the aircraft industry, and for those with ability and capability for hard work 'the sky's the limit'.

Some More Books to Read

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